



REPORT
ON SUPPLYING
THE CITY OF QUEBEC
WITH
PURE WATER:

Made for the City Council

BY ORDER OF

GEORGE OKILL STUART, ESQ.,
MAYOR OF QUEBEC.

By GEORGE R. BALDWIN,
CIVIL ENGINEER.

BOSTON:
CHARLES C. LITTLE AND JAMES BROWN.
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REPORT.

Charlestown, April 3, 1848.

DEAR SIR,

IN compliance with your communication dated July 1st, 1847, requesting that I should repair to Quebec for the purpose of investigating the practicability and cost of supplying that city with pure water, I commenced a reconnoissance of the neighboring streams on the 11th of August following, to ascertain their relative capabilities and facilities for furnishing the requisite supply.

Owing to the severity of the winters, nearly all the minor streams in the vicinity of the city are arrested in their course by the entire congelation of their waters — and remain in that state during the greater part of that season; rendering them unsuitable for furnishing an uninterrupted supply, unless artificial reservoirs of great capacity were constructed to hold some four months' provision of water. As the coldness of the climate rendered the small streams unsuitable, there remained for examination only the two larger rivers, the St. Charles and Montmorenci; neither of which presented any apparent objection, either in regard to their elevation, quantity or purity of their waters, or in regard to the distance to which it would be necessary to convey the water by artificial means. Therefore, considering these sources sufficient in every respect, surveys were made to ascertain the practicability and cost of an aqueduct which should terminate in the city on the high ground at the junction of Scott street with St. Lewis road, where a reservoir could be constructed of ample height for

forcing the water into every house in Quebec, and probably to supply the lower portions of the citadel enclosure.

The bountiful and salubrious waters of these two rivers at once discouraged any thought of abandoning them for a nearer supply by means of steam or water power, which, although it might result in a cheaper method of supplying the city, should not, to follow the recent examples of some of our large cities, on that account alone to be preferred.

CHARACTER OF THE ST. CHARLES AND MONTMORENCI RIVERS.

Although neither of these rivers were explored by myself much above the points at which the water would be taken, if taken at all, it may be well to allude to them, giving such casual information as was gathered from different individuals, and other sources; in particular that part acquired from a journal kept by William Ware, Esq. deputy provincial surveyor, who made, in the year 1837, an exploration of the sources of the Montmorenci, Saluriski and the Huron branch of the St. Charles, for Peter Patterson, Esq. the present proprietor of the Beauport Seigniory. It appears by this journal that the country, after reaching a point twelve or fifteen miles north of Quebec, was then in a state of nature, and that it was with difficulty that he with his Indian assistants could penetrate that inhospitable region, having to carry provisions for their support during their absence. Mr. Ware ascended the Montmorenci, and at about eleven miles from Quebec (as measured on the sketch of his route accompanying the journal) he passed a mill-stream on the right bank, and at thirteen miles another small stream on the same side of the river, carrying a mill, (Priest's); at fifteen miles one of the main branches of the river diverges to the left, having a breadth of sixty feet, and a course nearly north, its origin being among the mountains, in close proximity to the source of the Huron branch of the St. Charles, the two streams running side by side for about five miles, within one mile of each other. This stream drains a strip of country equal to about sixteen square miles. At twenty-four miles from Quebec, according to the sketch, the Montmorenci has smooth water for about two miles, at a place

called the "Great Fishery," where the immediate banks are low ; but the mountains are near, and covered with mixed wood. At twenty-seven miles, near the head of another great fishery, where the water is smooth, the river is divided into two main branches, each draining a country about twenty-eight miles long, by six or seven miles wide. Mr. Ware followed the eastern branch, (Snow River) which is very precipitous in its course, originating at Snow Lake, twenty-one miles from the Forks. It rises in that distance, according to his daily estimate of the inclination of the stream, about sixteen hundred feet. The country on each side of this part of the river, like that for twelve miles below the Forks, was greatly broken into mountains, varying from nine hundred to three hundred feet in height, the highest mountains being at the Forks. At the Forks he found the hard wood to terminate. Above, the growth consisted of small spruce, balsam and white birch ; the moss covering everything on the surface of the country, much of which was entirely divested of the soil. At eleven miles up Snow River he passed a stream coming in from the east, which seemed to have connection with a large lake, discovered from the top of a mountain, about three miles distant from the river. This stream yielded about one-third of the water flowing in Snow River, below the junction.

While at Snow Lake on the 12th September, he remarks, that it rained and snowed throughout the night, and on the 15th September, the party being still at the lake, ice was formed in their drinking cups. The Lake is about seven and a half miles long, ranging nearly north and south ; the eastern shore is low, while the western is covered with mountains, rising from three hundred to six hundred feet. Two miles north of the north end of Snow Lake, which point he designates as the source of Snow River, the party came to a lake two miles long and three quarters of a mile wide, supposed to have connection with Mal Bay (Malbaie) River.

From the south end of Snow Lake the party passed across the country in a westerly course six miles to the west and main branch of the Montmorenci, the timber of spruce, balsam, &c., and of the worst description, varying in quality according to the elevation of the country. At about three miles from the lake, a small branch of the Montmorenci was crossed, running

north. Some other minor branches were afterwards crossed, two of them running north, another south. Reaching the main branch, they followed down its winding course through a swampy district, covered chiefly with larch wood for about two miles, when their route was directed towards the south-west, across the country to the head waters of the eastern branches of the Saluriski River; thence following near the crest of the eastern watershed of that river for fifteen miles, until, at a distance varying, as estimated on the sketch, from two to four miles from the Montmorenci, the party came to the source of the Huron branch of the River St. Charles, at a point twenty-three or twenty-four miles from Quebec.

The head of the Huron River is among the mountains, and very near the source of the sixty feet branch of the Montmorenci, already noticed. The Huron here descends according to estimate, one thousand one hundred feet in a distance of two and a half miles, following the bases of steep and lofty mountains, covered with spruce and birch timber. Here occurred another severe frost on the 21st of September. From this river a divergence was made into the parallel valley of the beforementioned branch of the Montmorenci, and following that stream the party soon intersected their upward track.

From this condensed account of the river region traversed by Mr. Ware, we are to infer its character to be such as would be likely to furnish the purest of water; little liable to be animalized with visible or invisible animalculæ, or become very rapidly unwholesome by stagnation. The very great descent of the streams, so little interrupted by smooth or gentle currents, makes it certain that the water would arrive in the greatest purity at the points where it would be taken and conducted by an aqueduct to the city. And the inhospitableness of the region, made so by the extreme barrenness and roughness of its surface, would forbid its being used to any extent for agricultural purposes.

I was informed, by persons who knew the country about the sources of the River St. Charles, that the small western branch of that stream had its rise like the Huron, and wound its way like that river among the mountains. The western branch passes through Lake Larron, just before the junction at or near the head of Lake Charles. Lake Larron is said to be very deep, and embosomed in the mountains.

Lake St. Charles is a very long lake, divided near the middle by narrows, with high ground on the west; the eastern shore for an extent of a mile or two is comparatively low and covered with wood. East of this the country becomes elevated, and forms a portion of that range of primitive hills which Lieut. Baddely, R. E., has described as "commencing at Cape Tourment, thirty miles below Quebec, on the northern shore of the St. Lawrence, where it forms a conspicuous dome-shaped headland, trends away to the westward in a series of consecutive mountains and valleys; the former holds a course nearly parallel to the St. Lawrence, and preserving an average distance from it of ten or twelve miles. Beyond this line of demarkation to the northward for many miles, no '*land of promise*' for the settler is met with; and the semi-civilized Indian traverses this inhospitable region, in the pursuit of the moose and the caribou, consoled by the reflection, that here, at least for many years to come, his wanderings will suffer little interruption from the white man.

"The highest of this range is considered not to exceed two thousand feet of altitude above the St. Lawrence, but usually falls much short of it. The country which it traverses has been explored, but by no individual possessed of sufficient geological knowledge to allow him to describe the rocky masses met with, in language sufficiently scientific to be intelligible to the initiated. However, an examination of those off-spurs and boulders which lie nearest the town, has led those who understand the subject, to infer, that granite, granitic gneiss, mica slate, (rarely); syenite, syenitic gneiss, hornblende slate, and primary greenstone, are the species of rocks which most prevail." *Picture of Quebec*, p. 444.

The upper part of Lake St. Charles is said to have a depth of one hundred feet; its western shore is rocky, with deep water, while the eastern has shoaler water with a sandy bottom. The lower division varies in depth from ten to twenty feet, excluding the shoal parts near the shore. The bottom is composed of sand and mud; the latter an extremely fine sand, probably the finer part of the debris of the primitive district above, which has been brought through the upper division of the lake during floods, and before reaching the quick water at the outlet, has been deposited where it is now found. Should

the flood water, as it flows through the lake, act upon this sediment, it would be conveyed down the River St. Charles, and be a source of annoyance by being carried through the aqueduct to the city, were there not a subsiding reservoir to arrest it, constructed at Lorette, or some other point, where the supply might be taken. The east side of the lower division of the lake is said to be bounded by a rocky or hard shore, except about half a mile next above the outlet, where there is an extensive swamp running back to the foot of the high land, about two miles distant. The west shore of the lake, below the narrows, was represented to be high, with the exception of a patch of hard bottom land, about one quarter of a mile wide from the lake, at the Inn, which is annually flooded to the depth of six or seven feet, as is the swamp on the opposite shore of the lake, for a short time during the freshets in the spring of the year.

The ice of the feeders of this lake does not float down in floods, but is dissolved in place by the warmth of the water and sun; neither has the water the power to break up and force down the outlet of the lake the ice formed in the lake itself. We have, therefore, nothing to fear from the action of ice on any artificial works to be erected at the head of the aqueduct.

The west shore of this lake has been occupied many years, and there can be enumerated now, within two ranges of lots, thirty-eight families.

On my visit to the place our route lay along a road which crossed the outlet where the bottom land was about a mile wide. The river, at that point, had a velocity of about one mile an hour, and a level of about seven feet below the surface of the road and bordering forest. This low ground, which extends, perhaps with some interruptions of high ground, to the head of the rapids at Lorette, is periodically flooded, like the swamp on the lake. The course of this part of the river is very serpentine. A distance of seven miles by this course is said to be three miles longer than a straight line. The velocity of the current here is such that a canoe left to itself would float down the seven miles in about five hours. There are but few shallows where the water is reduced in depth to one and a half or two feet; and the width varies from eighty to one hundred feet. The fall is so little, according to the repre-

sentation of others, that a dam could be made at Lorette, which would flow the lake and turn it into an immense reservoir, from which any deficiency could be supplied in the natural flow of the river during an extreme drought in summer, or, what is more likely to happen, a prolonged frost in the winter. Instead of building a high dam at Lorette, the same effect would be produced by deepening the shoaler parts of the intermediate portions of the river. But this would not be so desirable a course to pursue as the other, on account of the greater liability of having the water made turbid by abrasions from the banks of the stream between the lake and dam. A high dam would tend to remedy such a result by causing a diminished current; but, on the other hand, the bordering low ground would be flooded oftener, and to a greater depth.

Between Lake St. Charles and the above-mentioned road the River Jaune, a large tributary of the River St. Charles, enters from the north, having a developed course, including the two main branches, of about thirteen miles. On this tributary are located three lakes, Lake Beauport, Segamite, and St. Sebastian. The first is the largest, and distant four or five miles north-east of Lake St. Charles.

There is another stream that rises about two miles west of Lake Larron, from whence it sweeps round towards the west, returning into the St. Charles, after a course of some ten miles, not far above Freeman's dam, at Indian Lorette.

On the 12th of August, I examined the lake water taken up in a boat from the middle of the lake; its color was of the purest white, and perfectly sweet to the taste; but when the river water was examined at Lorette, after a few rainy days that followed a long season of dry weather, it had a slight tinge of yellow, like bog water, with a taste a little astringent, but such as to be scarcely discernible. It was stated by the inhabitants at the inn, that the lake water has at times a yellow or reddish color, caused probably by bog water, or the wash of the swamps.

A sample of the Montmorenci water, (No. 1 of the Analysis, given in Appendix A,) taken up on the 11th of August, at Mr. Patterson's dam, top of the Great Falls of Montmorenci, was as white, sparkling, and as free from all bad taste as that

of Lake St. Charles, (No. 2 of the Analysis,) but apparently many degrees colder.

Another sample of the Montmorenci water was taken up on the 8th of September, at a point about a mile above the Three Falls; the river having been affected by some six days of rain that intervened between the 11th of August and 8th of September. This sample (No. 4) had a higher color of the bog, or swamp, than any one of the nine samples left with Professor Silliman, for analysis.

Sample No. 5, taken up September 24th, at Mr. Patterson's Bridge, at the head of the Great Falls, was a large one of about two and a half gallons, it was much less tinged by the bog than No. 4.

A large sample, No. 6, two and a half gallons, was obtained at the east end of Freeman's Dam, at the head of the Rapids at Indian Lorette, where it is proposed to tap the river for supplying the aqueduct. This sample was very nearly of the same tint of sample No. 5. In taking this up it was observed that there were numerous white particles carried along in the stream, both upon and below its surface; I took these particles to be sawdust, and as they could be seen before they reached the mouth of the bottle, most of them were avoided in taking up the water.

In all these samples, from No. 1 to No. 6, inclusive, with the exception of the sawdust, there was scarcely a particle having the character of sand or mud, to be detected by the naked eye. They were all perfectly translucent, and only tinted yellow, as before mentioned. Frequent analyses of the bog or peat water have of late been made by the most experienced chemists and physicians of the United States, and they all assert the harmlessness of these colored waters.

As to the sufficiency of the St. Charles and Montmorenci, independently, yielding at all times a full supply of water for any probable increase of the city for fifty years to come, after what I have seen and learnt from reputable persons, concerning the flow of these rivers, I have no doubt. The Montmorenci is the largest of the two rivers. In comparison with the St. Charles it bears more the character of a mountain torrent, suddenly raised to its maximum, and as quickly reduced to its minimum discharge, but probably furnishing

more water at all times. The St. Charles, on the contrary, (if we confine the remark to that division of the river below Lake St. Charles,) has considerable constancy, and does not, in the greatest freshets, rise more than about eight feet at the Lake, and probably not more than three or four feet on the dam at Lorette. I was so well satisfied as to the capability of either of the two streams to supply a population of 100,000, or even 200,000, that I took no particular pains to measure their discharges. I roughly estimated, however, that of the Montmorenci, when it was first visited, on the 11th of August; at which time it was stated to be, by those who well knew the river, very nearly at its lowest stage. The discharge then must have been equal to one hundred and fifty cubic feet—perhaps two hundred cubic feet—per second. The discharge of the St. Charles, at Indian Lorette was probably about two-thirds as much at that time.

PRESENT AND PROSPECTIVE WANT OF WATER FOR THE CITY.

The quantity of water the aqueduct is to furnish is a point to be settled before going far into the details of the work, as the size of the conduit conveying the water from the source in the country or other point of supply, is dependent upon it. In the present case I have fixed the supply at 480,000 cubic feet per day of twenty-four hours, equal to 5.55 cubic feet per second, assuming for the purpose the number of inhabitants eventually to be supplied, at 100,000—and that each individual, man, woman and child should require thirty imperial gallons, or 4.8 cubic feet a day. But it is not to be understood that this is the exact quantity each individual would receive in practice. This is only an average of what would be used by the different tenants. Some families would not receive more than two-thirds, others not more than one-third of this average rate; while manufactories, and other establishments of the kind, would take more or less, according to the nature of their business; as will appear by examining the table given in Appendix B, which with the other tables, C, D, E, of the statistics of the Fairmount and other Water Works, have been compiled from annual reports, parliamentary docu-

ments, and other authentic sources. The table alluded to, shows the range of supply to a tenant at Philadelphia to be great, the rates there, varying from \$100 to \$150, and in one instance reaching \$750 per annum; the quantity of water varying probably in the same ratio. In that city, where the water is profusely used for cleansing the sidewalks and streets, the average daily consumption for ten years from 1834 to 1844, was 178 imperial gallons per tenant. (See Appendix E). In London, the five water companies on the north side of the Thames (see Appendix D) delivered 173.4 gallons to each tenant in 1820, and in 1827 supplied 172.3 gallons; and the whole eight companies (on both sides the river) delivered in 1827, 163.2 gallons per twenty-four hours to each tenant. We may therefore, conclude, that 150 gallons to a tenant, or to each five individuals of the population, would be a proper supply, if we make all suitable allowance for the difference in climate between the places cited and Quebec; and also the difference there probably would be in the use of the water for manufacturing purposes.

Having settled the unit of supply for an inhabitant, we have still to consider the aggregate quantity the works should be capable of supplying, without exceeding the present or prospective wants of the city. This question would be settled at once, were it proper to base it on the present population; but common prudence demands that we should look beyond the immediate wants of the city, on a subject which requires at any rate a very large expenditure, and to see, if a very small addition to the capital to be invested in the works, will not provide for a very material increase of the city; and perhaps be a primary cause in such increase, by the facilities and comfort its results would offer to settlers. All estimates show that a very considerable addition to the supply of water by an aqueduct, may be obtained by a very small addition to the money expended; for many of the details of that part of the water work connected with the introduction of the water into the city for distribution, would be common to a small or large supply. The item which would be the most affected, belonging to this part of the work, supposing the water to be brought from a distance, is the conduit that is to convey it, and the cost of this is but slowly augmented as the quantity of water is

increased. The other expenses of this part of the work (such as the dam, reservoirs and their appendages, bridges, culverts, and damages) are raised little if at all, by increasing the size of the conduit.

It is usual, on these accounts, to provide for years to come. And I have, therefore, assumed the population eventually to be supplied, to be one hundred thousand.

According to the Statistics of Quebec, furnished by Mr. Joseph Hamel, City Surveyor, the population of the several wards was, in 1842 and 1847, as stated in the following table. The entries under the head 1842 were taken from the census; those under 1847 were taken from the assessment books.

Wards.	1842.		1847.	
	Population.	Families.	Population.	Families.
St. Lewis	2,797	328	2,634	310
Palace	2,282	248	3,071	360
Champlain	3,733	531	4,330	610
St. Peter's	3,624	705	4,916	803
St. Roch's	10,850	2,081	12,665	2,510
St. John's	8,715	1,639	8,539	1,510
Total	32,001	5,532	36,155	6,103

Besides this table, the Quebec Guide for 1844, states the population of the several wards, seminary, convents, &c. (apparently obtained from a census taken that year,) to be, exclusive of Banlieus, 32,876

Banlieus being 2,797

And the whole county of Quebec, per same census, 45,676

Using the numbers given here for the population of the city wards, we find the increase and the compound ratio of increase to be as follows:

Increase in 5 years, from 1842 to 1847 = 4,154, and the compound ratio of increase = 2.47 per ct. per annum.

Increase in 2 years from 1844 to 1847 = 3,279, and the compound ratio of increase = 4.87 per cent. per annum.

Now computing on the present population, by the first ratio of increase, we find there would be at the end of 41.7 years a population of 100,000 souls. But using the second ratio of increase, viz. 4.87 per cent. per annum, there would be 100,000 inhabitants at the expiration of 21.4 years from the year 1847. Should we go back to the year of capitulation, 1759, eighty-eight years ago, when the population was 6,700, we should

find the increase by the same rule to have been about 2 per cent. per annum; and if the city should not increase in a more rapid rate, we should have to anticipate 51½ years before the entire capacity of the conduit would be put in requisition. But there is little to apprehend, that the rate of increase will be so low as that suggested in the last case, for many years to come. The prospect is the reverse, a much higher rate than either the first or last case exhibits may be fairly inferred, under the influence of the modern mode of communication by railroads. The railroads to New Brunswick and the United States, if completed will much augment the ratio of increase; the probability is, that the anticipation of the completion of the railroads alone has had a very material effect already on the population of the city, accounting, in part, for the excess in the ratio of increase for the last two years. I think these facts warrant the assumption that there would be a population of 100,000 at the expiration of thirty years from this time.

Allowing the result to be as stated, the question may be asked, will the whole population take the water at the expiration of that time? It is found that the city proper of Philadelphia, (excluding the Districts) furnish a tenant to the water-works for each $7\frac{1}{3}$ of its population.* A "tenant," therefore, in that city, is synonymous to $7\frac{1}{3}$ individuals—which is 46½ per cent. more than we have allowed, in considering a tenant at Quebec equal to 5 individuals. But we suppose there would be a greater portion of the population in Quebec—indeed, very nearly all—who would pay for pure water, because it is impossible to procure it by wells, or other sources, at a cheaper rate. Nevertheless, should this not be the case, there is a reason for providing a full supply in the necessity for the extra quantity of water, which the pipe should be capable of delivering during a hot season. This is plainly elucidated by the Fairmount Water Statistics, given in the Appendix; and also in a letter from Frederick Graff, Esq. the Superintendent of the Fairmount Water Works, to a member of the Boston Water Commission, for 1845. In this letter he states: "In one week of hot, dry weather, from August 6th to 13th, this year," (1845) "we pumped 5,116,674 gallons, supplied to 20,399

* J. B. Jarvis and W. R. Johnson's Report on Supply of Pure Water for the City of Boston. p. 112.

tenants, which is for each nearly 251 gallons." (ale.) "This quantity should be calculated for at Boston, to cover with certainty all incidents that may occur, either by means of dry weather, great consumptions for fires, or carelessness in the distribution; 28,082 tenants, the first six months in 1844, used, per average, 162 gallons," (ale) "each tenant; 20,399 * tenants, the first six months in 1845, used 187 gallons each — which makes an excess of water used this year by each tenant, per day, over the consumption of last year, of 25 gallons. The excess, I think, has been produced by the dry weather and excessive heat, together with more frequent bathing, and washing the streets." — Here we have, from undeniable authority, both the amount of water used in hot weather, and the advice to provide for such excess in the erection of water works. Taking the quantity he gives, turned into imperial measure, (255 gallons) and comparing it with the average quantity we have already given as used in that city, for ten years following 1834, viz., 178 gallons, we find there must be provided for, an excess of supply, 43.26 per cent. more than the average demand, which nearly compensates for the difference between taking 5 instead of $7\frac{1}{2}$ individuals of the gross population, as constituting a tenant. These considerations, we think, justify us in fixing 480,000 cubic feet, or 3,000,000 imperial gallons of water a day, as the proper quantity to be contemplated, in giving dimensions to the details of the work. The amount is probably as large as the circumstances of the case warrant.

The quantity of water taken from the St. Charles and St. Lawrence Rivers, both in winter and summer for the supply of families, and its quality, may now be stated :

St. Lewis Ward	3,061,600	gallons	per	annum.
Palace "	2,579,200	"	"	"
Champlain "	1,268,800	"	"	"
St. Peter's "	3,340,480	"	"	"
St. Roch's "	9,689,600	"	"	"
St. John's "	683,120	"	"	"
Total annual consumption	20,622,800	"	"	"

* This number was partly assumed by Mr. Graff, as he states in his letter. The number for the whole year appears in the annual report to be 20,165. See Table E, in Appendix.

This supply in 1847 was equal to a daily consumption by each family of 92.58 gallons. The water is nearly all taken up in the course of a few hours while the tide is out, and the St. Charles has discharged most of its tide water, and the later it is taken up (before the return of the tide) the purer and better is the water esteemed; and it is at such times that the drinking water is secured for families who are particular to have the best.

The places usually resorted to by the water-carriers to procure their supply, are as follows:

At the site of the old Dorchester Bridge, north of the Marine Hospital, which is the highest place on the St. Charles, except St. Ours street, at the General Hospital, where the water-carriers, in any considerable number, go for their water. This locality is considered the best for table use.

The second place next below is the landing at the foot of Crown street.

The third place in order, following down the city side of the St. Charles, is at the foot of Ann street, just above the present Dorchester Bridge; here a very large portion of the water is taken up, most of it for St. Roch's Ward, but much also is conveyed to the higher parts of the city.

The fourth place in order is near St. Paul's Market, at the landing place on Light-house Wharf, where the Gas Company are now establishing their works.

The fifth principal place is at the Market Landing in St. Peter's ward, in the Lower Town.

The sixth point is on the beach, called *Cul de Sac*, at the north end of Champlain Ward. Both this and the fifth locality furnish water, which may be considered as properly belonging to the River St. Lawrence. The water at all the other points, if taken up at extreme low water, or just before the return of the tide, may with propriety be called St. Charles water; but it still may contain a small portion of water that originally descended the St. Lawrence, and consequently may contain a portion of the impurities which the flood tide carried up the river, from the outlet of the sewers and other sources of filth.

The interesting and valuable analysis of the Quebec waters by Professor Silliman, with the curious if not useful report of Professor Bailey, of West Point Military Academy, on the

microscopic contents of the same waters, (see Appendix A) show them to be very pure. The samples for analysis were taken up with every precaution to obtain them free from accidental impurities. They are, in my opinion, greatly liable to such impurities, and particularly so at the time when it is usual for the carters, with their horses and water barrels, to resort to the several watering places, entering pellmell into the shallow water, lading and filling their barrels with all possible despatch, regardless perhaps of what their buckets may contain.

To show that on such occasions, noxious, offensive, and even poisonous impurities may be inoffensively taken up, and conveyed for domestic uses, we have only to allude to the fact, that the common sewers charged with the *debris* of houses and cesspools, or private vaults, and the poisonous waste of manufactories, do discharge into the St. Charles or the St. Lawrence Rivers; three or four of the principal ones having their *débouché* at the very points where the water is procured by the carriers.

Three of the Quebec waters, analyzed by Professor Silliman, were taken up at the above specified watering places, (see Appendix A) viz.:

SAMPLE No. 7. Water taken up at the site of the Old Dorchester Bridge, at 2½ P. M., Sept. 25, 1847, just before the return of the tide to that place, the water still running out. Bottles filled from the stream at a distance from the shore.

SAMPLE No. 8. Taken up at low tide, Sept. 27, at 3½ P. M., at the foot of Ann street, St. Roch's Ward, at a place away from the shore where the carriers take their supply — the water at the point being from 12 to 14 inches deep — wind fresh up the St. Charles, which made the water quite turbid.

SAMPLE No. 9. Taken at the *Cul de Sac*, Champlain Ward, within one hour after Sample No. 8 was taken up. The wind still blowing quite a breeze up the St. Lawrence, and into the Sac, rendering the water turbid for some considerable distance from the shore. Not being able to procure a sample sufficiently pure from the beach, took one from a carrier's barrel, who had, at our request, taken up his supply as far out as possible into the river, still the sample was quite turbid.

It may be well to observe here, that the sediment deposited in the bottles containing the different specimens of water, was

excluded from the analysis, as Professor Silliman has informed me since the receipt of the report, because in fact they formed "no part of the proper contents of the waters." It was observed when the specimens were taken from the bottles for Professor Bailey, that the original turbidness of the water could not be reproduced by any ordinary agitation of the bottles; the sediment having agglutinated itself into little clots that would not redissolve.

All the bottles, thirty-three in number, containing the nine samples of Quebec waters, were new, and were all furnished with well ground glass stoppers; and on taking up the samples the bottles were always thoroughly rinsed in the water of the locality. They were afterwards kept secure with leather tied over the stoppers, and with one or two exceptions, were kept stopped until their delivery into the possession of Professor Silliman, excepting, however, the opening of nine bottles for the small specimens left with Professor Bailey, who had the kindness to consent to examine them for animalculæ, &c., under his powerful microscope.

The quality of the water of the city wells is very inferior, and therefore many of the families buy their supply of the water-carriers, paying various prices, according to the quantity and distance it has to be conveyed; ordinarily at the rate of about \$7.50 a year per one hundred imperial gallons, for a family of five individuals. It is estimated that five-eighths of the population use snow water in the winter, and river water in the summer season. Some of the more opulent families in St. Lewis and Palace Wards, pay from thirty to forty dollars per annum for river water, notwithstanding they have wells on their estates, the water of which is used for washing dishes, and other culinary purposes. The stables in the same wards use large quantities of river water. One of them I understood kept a man and team employed almost all the time bringing water for the establishment. I was informed by a gentleman residing in St. Roch's Ward, not far from the watering place at the foot of Ann street, that he purchased for his family of nine persons, three barrels a week from the carriers, and paid them at the rate of \$15.60 a year.

There are about 112 water-carriers, each owning a team valued at fifty dollars.

The quantity of water consumed by the military depends upon the strength of the garrison; they now use the river water only for washing clothes; they have a large cistern and some wells within their inclosures, and these furnish the remainder of water which they require for culinary and other purposes. But should the Water Works go into operation, the different military establishments would become, no doubt, large consumers.

The wells of the higher portions of the city are sunk in the clay slate rock, which is thinly covered with earth, and consequently the water is very impure, having much the character of surface water, there being no depth of soil to purify it by filtration before it enters the wells.

LORETTE LINE OF AQUEDUCT.

It is proposed to take the water for this line from the River St. Charles at Freeman's Tannery Dam, at the head of the rapids, thirty chains above the church at the Indian village of Lorette; assuming the level of still water above the dam as it was found at the time the survey was made, to be that, to be maintained as the fountain head of the Aqueduct. The works which are proposed here are a Dam, Receiving Well, Conduits in masonry, a Reservoir of Subsidence and its appendages, consisting of a Wasteway, Culverts and Well, for regulating, straining and directing the water to the cast iron pipe leading to the distributing reservoir in the city.

The dam would be placed at right angles with the general course of the river at this place, and located just below the present dam. The body of the work to be constructed of stone, with a water stop of brick placed as a facing against the up river side of the stone work, the top or exposed part of the stone and all the brick work to be laid with hydraulic cement, sinking the foundation six feet below the bottom of the river. A strong abutment wall on the left bank will extend up and down the river a suitable distance, to guard against abrasions by the water, and at the same time to form a head to a cylindrical conduit of hydraulic brick work, designed for conveying the water to a Receiving Well, placed about fifty feet in the rear,

measuring at right angles with the face of the wall or general course of the river. The dam would have a sluice near the right bank, where the water for the tannery could be discharged. From the Receiving Well it is proposed to convey the water to the Subsiding Reservoir, by a covered Conduit in masonry about four hundred feet long, laid parallel to the river. The Receiving Well would be furnished with strainer and regulating gate, and enclosed by a circular building in brick work, to protect it from intrusion and frosts.

The Subsiding Reservoir, represented on the profile of the line (No. 2), would extend about six hundred feet along the line of survey, being divided by it very nearly into two equal parts. The high embankment forming its southeastern, or lower boundary, would intersect the surveyed line in the meadow at Station 118, and occupy the space between the Indian Chiefs lane and the river. The east embankment would follow the lane, and the west the river, both extending to the high ground at the north side of the Reservoir. About three quarters of the area enclosed by the embankments would be cutting, calling the bottom of this part of the Reservoir eight feet under the level of high water, or eight feet below Station 120 or still water of the river above the dam. It is estimated that the earth to be removed would be sufficient to form the surrounding embankment. At the north-west corner of the Reservoir would be the most suitable place for an uncovered or open Wastewei, unless one could be formed, in combination with the Pipe or Regulating Well and Culverts, to be inserted in the high embankment at Station 118, or at the south-eastern angle of the Reservoir. The dimensions and capacity of this Reservoir would be as follows :

Superficial area at high water level, 240,486 square feet, or
5.52 statute acres.

Superficial area at low water level, 210,390 square feet, or
4.83 statute acres.

Cubic contents between high and low water levels,	1,803,504 cubic feet.
Add for the deeper part of the Reservoir,	43,200 " "

Total capacity equal to 3.85 days' supply for the city,	1,846,704 " "
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From Station 118, the surveyed line for the iron main passes down the meadow to the left bank of the St. Charles, where it continues along the bank between the Indian village and river, crossing the great road between the Indian church and the ancient Indian grave yard, and then enters the church land, which occupies the space between the road on the north, and the deep ravine the river has cut for itself in the limestone formation below the great cascade on the south. The line then passes along the left bank of the river, south of Lepire's and Lafonte's dwelling houses, crossing the Quebec and Lorette river road in the hollow near Mrs. Pinet's house; thence following the low ground east of the river road, descends into the fields near Peter Falardeau's house, where the line takes a straight course to the isolated barn on the left bank of the St. Charles, west of the Vacherie or Pointe Aux Lievres, at Station 53. This straight part of the line may be varied considerably either to the right or left, without altering materially the cost of the work, provided the large brook at George Bederd's house (Station 93) is crossed near the place it is crossed by this survey. After passing this brook, the line might perhaps with advantage be deflected more to the south, and pass the steep bluff in the deep ravine cut by the little brook, about four chains west of Station 38, and from thence to the barn abovementioned, keeping south of the surveyed line, and avoiding the little brook at Station 64. From the isolated barn the Aqueduct would go straight to the foot of Dorchester, at St. Peter's street, crossing the River St. Charles at the Point nearly at right angles with the course of the river at that place. From Station 47 at St. Peter's street the main would follow the line of survey through Dorchester to its junction with St. Valiere street, cross the latter in a diagonal direction, and ascend the steep rocky bluff to its crest at the foot of St. Claire street. Thence through that latter street, crossing St. John's street and the private lots on its southern side, enter and continue through Scott street to Chemin de la Grand Allée, or St. Lewis road; thence crossing that road, diagonally terminate at the west corner of the Ursuline Nuns lot, where we have supposed the Distributing Reservoir would be located.

The country portion of this line could not be much more favorable than it is for a conduit to convey water. The line is so

direct and free from undulations, that the effect of curves may be neglected in the computations for fixing the size of the pipe. The surface of the ground is particularly uniform, requiring only in a few instances, embankments or cuttings that would in any essential degree interfere with the farmer in tilling his land. The soil is also favorable for executing the work, and will we think stand with a slope no greater than that assumed in the estimates, and given in the cross section of the trench on Plate No. 2. We think the soil is also favorable in regard to its corroding action upon the cast iron of the pipes.

It is quite certain that rock would not be encountered along the country part of this line, if we except that portion between Peter Felardeau's house and the subsiding reservoir. I think the character of the sides of the deep chasm the river has excavated close alongside the line here, shows the chance to be small, that rock in place would be met with below the Indian Church, at the depth it would be necessary to go to secure the pipe against frosts. At the cutting across the road at the Church, the rock might be found at the bottom of the trench, for it crops out at the bridge near by, whence to the Great Cascade it occupies the whole breadth of the river, and forms the wall over which the river falls. This rock is of a hard quality, I suppose of the primitive formation, gneiss, and different from the limestone rock below. Should the rock below the church interfere with the position of the pipes we have assumed, they could be elevated without much inconvenience, and be protected by an embankment.

There are but three or four water courses, except the St. Charles and the large brook at Bederd's that would require any expense, except in some instances, where it would be necessary to divert them to a lower point on the line, where they would pass over the pipe without interference. A culvert would be required at Station 64, unless a more southerly course was taken, although I have supposed the water of this brook, before it reaches the line near Station 65, to be diverted across into the brook valley below Station 64, making it unnecessary to put in a culvert next to Station 65. Another culvert I believe to be unavoidable at Station 60, and another at Station 54. At Station 52, or near Station 50, should be a well for a waste cock and pipe, these points being at the extremities of the lowest

part of the pipe. This work is necessary to furnish the means of drawing off with the water any accumulation of sand or other substance, that may from time to time take place in the pipe. Either of these points would answer, both being near the river, into which the water and sediment could be directed at little cost.

The bridge across the St. Charles at the foot of Dorchester street is a large and important item in the estimate. It has been adopted as a necessary part of the work; but it would also be valuable as a new and important avenue into the city, if connected with a road to traverse the line of aqueduct as far at least, as the St. Claire and Bunaventure Roads, from whence it might be continued and make the shortest route to Indian Lorette, so much resorted to now by strangers and parties of pleasure, and likely to become more and more so as the city increases in population. It would, we are satisfied, be good policy for the landholders along the line to aid and encourage such a project; their lands bordering the road would be greatly enhanced in value, and sought, for country seats, for agricultural and other purposes. The part in the vicinity of the River St. Charles, could be laid out into streets and lots, and allow the city to expand in a direction now impracticable for the want of a bridge and road in connection; and there would exist there also a free communication by water with the lower parts of the city and the shipping in the River St. Lawrence. If there is not a bridge the pipe must be carried under the river, by some means or other. This could be done in the way contemplated by the estimate for the Montmorenci Line of Aqueduct, given hereafter in this Report; but it is our opinion that the facilities for operating at the Old Dorchester Bridge, where the other line crosses, do not exist on this, on account of the greater depth of water, and the absence of a free fall in the bed of the river below the site of operations. Still the plan alluded to or the flexible main,* adopted at Glasgow, in

* Mr. Philip Prebles, Engineer of the Quebec Gas Works, in a letter to the writer of this Report, from Scotland, dated March 22, 1848, states that, this flexible main, as it is called, has never been renewed since it was first drawn across on the bottom of Clyde; that the exterior surface of the pipes was as perfect as when cast; but the interior had some little knots (tubercles) of rust, which could be removed by the finger; he also states that at Edinburgh they were making some radical changes in the Water Works; and at Glasgow new Water Works were being constructed to supply a district of 97,000 inhabitants, by gravitation.

Scotland, would answer here, and cost considerably less than a bridge; but both plans would be attended with great inconvenience, in case repairs become necessary on that part of the pipe in the river, where they are more likely to occur than any where else; the pressure being equal to about 463 feet. So far as we are informed, the history of water works do not furnish any account of a head of water so great as this. The tunnel furnishes a superior method for getting across the river with the pipe; it should be so large that one, perhaps two large pipes could be laid through it, leaving space enough besides for inserting a new joint, should an accident require it. Two wells would be necessary appendages, one at each end of the tunnel, for the descent and ascent of the conduit, with provision for a waste cock and pumps, and houses to cover the wells. The expense of a tunnel has not been ascertained, but probably would amount to 25,000, or 30,000 dollars; supposing the river would have to be turned into a new channel across the point of land, in executing the work.

The bridge contemplated would be of cut stone masonry, with three arches of forty-five feet span each. The width over the arches, exclusive of the projecting mouldings, would be twenty-six feet, and the wings or return walls would expand to thirty feet. The whole length of the bridge, including the wings, two hundred and forty-nine feet. The pipe would pass the bridge on a level eleven feet above the base line of the survey, or high water of spring tides, and would be enclosed in a covered way in masonry, for the purpose of equalizing the temperature about the pipe, and giving access for repairs, and for further protecting it from frosts, should it be required.

On a portion of the line within the city limits, rock at a greater or less depth, would be found from the bluff at the foot of St. Claire street to the distributing reservoir; in some places it could be avoided in part by grading the streets anew, filling in and equalizing their inclinations, thereby saving much expense in quarrying for the water and gas mains, the service pipes, the common sewers and the private drains. In the estimates a liberal allowance, it is thought, has been made for the rock, but there was no data by which its amount could be fixed with much certainty. Where the rock was visible in the

streets, and bottom of open cellars, its presence was noted ; much of the distance, however, there was no indication that it was so near the surface of the streets as to interfere with the emplacement of the pipe.

DISTRIBUTING RESERVOIR AND DISTRIBUTION.

The lot of ground selected for the site of the distributing reservoir, for the purpose of the estimate, is that belonging, as we were informed, to the Ursuline Nuns ; now under a lease to the British government. It is situated on the south side of St. Lewis road ; and bounded on the other three sides by the government property. The lot next west is better adapted for a reservoir, on account of its greater breadth and altitude ; but as such a work constructed there might be considered to militate with the plans of the citadel defences, it was thought best to place it where it would probably interfere the least with the citadel, and be better commanded in case of invasion.

The surface of the lot selected is somewhat uneven, requiring at places high embankments. The embankment exceeds the amount of the excavation some six or seven thousand cubic yards. The quantity of rock is uncertain. This, like many of the levels used as data in computing the work, has been assumed from cursory observations made while running levels in the vicinity ; and is to be taken in the estimate as only an approximation.

At the west corner of the reservoir, the supplying conduit will be admitted by a covered gallery, accessible for examination and repairs as far as the middle of the embankment, where there would be a water stop in hydraulic masonry, through which the conduit would pass, and open into another circular gallery or culvert, having a free outlet into the interior of the reservoir. At the north corner, it is designed to place the wells, culvert and gallery for supplying the city mains — here the water will be strained before its admission into the pipes, with copper or canvas strainers — and a waste-weir provided for conveying off to the common sewer the waste water of the reservoir.

The dimensions given to the reservoir are as follows :

Length, inside, from top bank to top bank . . .	440 feet
Breadth " " " " " " " . . .	220 "
Length at surface of high water . . .	434 "
Breadth " " " " " " . . .	214 "
Length on bottom of the reservoir . . .	374 "
Breadth " " " " " " . . .	154 "

Cubic contents of the water prism, when the reservoir is full, or within two feet of top bank, making allowance for the culvert and wells, and masses of earth and masonry at the inlet and exit pipes, equal to $3\frac{1}{2}$ days supply for the city 1,500,000 cubic feet.

Surface, or high water level of the reservoir, is assumed, at 330 feet above Base line of the survey, or above high water spring tides at Quebec, and 114.60 below the fountain head at Lorette — the depth of water to be 20 feet.

The top of the embankment will have a breadth of 15 feet, the inside and outside slopes $1\frac{1}{2}$ to 1; the latter, on the west, north, and partly on the east side, will be supported by a revetment, of a height varying according to the inequalities of the ground. The estimate embraces the cost of paving the bottom and inside slopes of the reservoir with concrete, a necessary measure, should there be any considerable deposit from the water, requiring the deposit to be removed at intervals. It is my opinion, that in this case, we might omit part of the item, as the water to be introduced appears so naturally pure, or would be made so by the subsiding reservoir in the country. The sides of the reservoir not rock, should be lined to prevent the soil of the banks being washed into the reservoir, causing turbidness in the water by every little shower or breeze of wind.

In most cases the subject of distribution may be generalized in considering the cost of water works; but the geological and topographical character of this city demands more than ordinary attention in the preliminary examination for introducing water. One of the points alluded to, is the unusual existence of rock throughout a large portion of the city, very near the surface of the streets. The other is the very great difference in the levels of the different districts to be supplied. The first

affects materially the cost of laying down water mains and their correlative works, gas mains and common sewers; and the question, how the three shall be laid at Quebec, has already claimed considerable attention. It is our opinion that the works should be combined and executed under some well digested plan; especially where rock occurs to interfere with the excavations to any considerable extent in the narrow streets. In very wide streets there would be more reason for separating them, placing the common sewer in the middle of the street, and the gas and water mains on each side, either in contiguity or detached, as rock or earth might occur in such streets. I see no practical objection to the plan of laying a common sewer in or near the middle of a street which shall carry on its top the water and gas mains,—placed below the action of the frost. The sewer in such a position would be well adapted to receive the house drains, and other minor drains, and the pipes on top would receive such a support from the masonry of the sewer, that we might reasonably expect the repairs to be of little consequence forever after. The position of the mains on the side walls of the sewer would not interfere with the house and other drains any more than they would if placed independently, at or near the sides of the streets, and probably less; for in their proposed position the drains, in descending from the houses, would pass through the sides of the sewer below the mains. The same combination, of water, gas and sewerage, could be extended, under such a general system, to the service pipes; using the same excavation, whether of rock or earth, for them all. The water service pipes could, in such a combination, be laid in or upon the house drains, and receive a support therefrom, which would tend to protect them from derangement. In Paris on the Canal De L'Ourcq Water Works, it was designed, and I believe carried into effect, to lay a kind of drain, expressly for the purpose of enclosing the service pipe.* There, however, the main or submain, supplying the service pipe, was to be

* Ce tuyau de branchement sortira des égouts et galeries où les conduites principales seront renfermées en traversant la voûte par les puits de service dont il a été parlé. Pour faciliter la pose des tuyaux de branchement et leur inflexion en divers sens, s'il est nécessaire, le long des parois et de la voûte des galeries, ils seront fabriqués en plomb, à partir de leur origine sur la conduite principale, jusqu'à leur entrée dans les rigoles de maçonnerie qui les recevront sous le pavé des rues. *Girard.*

only tapped at intervals of 150 metres, (492 feet) the service pipe rising through a well or man hole in the top of the sewer ; and then laid in a covered conductor along the top of the sewer, and resting upon it, to the point opposite the place to be served. In that city the mains supplied with water from the Canal De L'Ourcq, were laid in galleries. Some of these galleries were built expressly for the mains, and had no other use than that of enclosing the pipes securely from accident, and allowing them to be examined and repaired at all times, without disturbing the surface of the streets. In other cases, there, the object was compound, the gallery serving, besides enclosing the main, the purpose of a common sewer. The smallest sewer designed, that was to contain a pipe, had a clear width inside of one metre, (3.28 feet) and a clear height of two metres (6.56 feet.) A pipe was laid in a sewer of this size, which constituted a portion of the train of galleries which conducted the waters of the Basin of Villette to the Fontaine des Innocens and other fountains.

The advantages of the Paris plan of laying water mains in galleries, over the English method of laying them in common earth, has been alluded to in a French work (Girard,) in the following terms : " That unquestionably the cost of distributing water in galleries, would be very considerable, particularly in Paris, if there did not already exist many sewers, in which we could, without additional expense, add to their first destination that of containing the water mains. The mains which convey the waters of the Basin de la Villette to the Fontaine des Innocens, to the Boulevard Bondy, to the Place des Vosges, and to Palais-Royal, are placed in galleries constructed within a few years, and in some old sewers of sufficient capacity. These we can visit at any time ; and for twenty years it has cost less for keeping them in repair, for an extent of more than 10,000 metres, (32,809 feet) than it cost in six months, (before making a general repair,) for repairing and maintaining the new conduit of the Faubourg Poissonniere, only 1200 metres, (3937 feet) long." And the author draws the following conclusions upon this subject : " That conduits buried in the earth, ought to have solid bearings on masonry at certain intervals, which should prevent as much as possible any unequal settling, which might cause a fracture. That in large towns

where the pavement of the streets is generally laid on filling, it is extremely advantageous to place the water mains in arched galleries, constructed under the streets, either for that special object, or what would oftener occur, and be more economical, that these galleries should also be used for sewers for the discharge of rain water and drainage of houses, and administer besides to the public health. Finally, that the advantage of arched galleries for receiving the principal conduits of distribution, having been proved for twenty years, it is suitable to profit by that experience, and not be exposed to the frequent disturbance of the pavement to seek for leaks, often without success, where the conduits are laid in a soil liable to settle, like that of the Boulevards, and most of the streets in the capital."

As the question in regard to the policy of uniting the sewerage, gas, and water works, is a matter that may properly be left for the future consideration of the city, the estimate has been made on the supposition that the pipes of distribution are to be laid down in the streets, by bedding them in common earth, in the usual way; estimating the cost of trenching, whether rock or earth, from the best information at command, making no allowance for any advantage that might be derived by using the channels already cut in the rock for the sewers, a course which might affect the result very considerably by reducing the cost of laying the mains. According to a plan of the city, exhibiting the sewerage as it existed in 1841, procured from Mr. Hamel, the city surveyor, on which the sewers (*les canaux*) were designated; the aggregate length of the sewerage transferred and measured on a new plan of the city, appears to have been from 9 to 9½ miles; of which 1¼ miles were in the wards St. Champlain and St. Peter's. In St. Roch's 2¼ miles; in St. John's 2¼ miles, and in St. Lewis and Palace wards, within the city walls, including a small portion supposed to be on the rock, outside of the three northern gates, on the bluff, 3¼ miles. Since 1841, the sewerage, no doubt, has been considerably extended, but we have no authentic account of the amount at this time.

The question, at what depth will the frost penetrate the earth, or freeze stagnant water, is somewhat important in many of the details of a water work; for water mains and service

pipes must be placed, if practicable, out of the reach of extreme frosts; and the usefulness of a Reservoir, if exposed to the open air, is dependent, to a certain extent, on the depth to which still water will freeze at its locality. Repeated inquiries while at Quebec, tended to fix the extreme depth for both earth and water at about four feet. This depth is corroborated by the published account of Captain Melhuish, R. E., on the demolition on the Glacière Bastion, at Quebec in 1828, where, in describing the effect of the explosion, he says "the only parts which descended in masses were the exterior revetment of the parapet, and the earth between that and the interior revetment, showing the enormous power of the intense cold in Canada, which strikes nearly four feet into the ground."

We have, agreeably to this information, fixed the depth below which the pipes should be laid, at four feet, and in designing the reservoirs and foundation of the masonry, the extreme coldness of the climate has been taken into consideration.

In the Appendix (F) will be found some thermometrical tables of the temperature of Quebec and Lower Canada. One from the Seminary at Quebec, another from a register kept by Mr. Watt, who had charge of the citadel telegraph for many years, where the observations were taken, undoubtedly with his usual accuracy. The other table was taken from the Reports of the Royal Engineers.

The other subject relating to the distribution, has regard to the effect of a great pressure of water on the pipes supplying the lower districts of the city. On this head, our experience in this country does not offer much direct information. From what I gather, however, from published discussions of water works in England and Scotland, I apprehend no difficulty in making the pipes tight, and maintaining them so. But there seems to be some objection to so great a pressure on the service pipes; and it has been proposed to relieve them of the superabundant pressure, by means of a regulating valve, inserted between the mains and submains or service pipes. The particular reasons for such a course are not fully explained. I suppose, however, they relate to the extra waste that takes place at the service and stand cocks, and perhaps to the noise the issuing water makes there, in some cases amounting to a

nuisance. Should there be a necessity for relieving the sub-mains from any undue pressure above what would be required for supplying the tenants in a proper manner, the city ought to be divided into districts of equal altitude, each having its proper pressure regulated, either by Subsidiary Equalizing Reservoirs or by Weighted Valves inserted in the submains, at their connections with the mains, descending directly from the Distributing Reservoir. The latter plan—should recourse to such an arrangement be demanded—would be the best; and could be applied at any time, after the distribution pipes had all been laid, and the experiment had been fairly tried, of furnishing water to the tenants under the full pressure due to the head at the Distributing Reservoir; if the precaution were taken to arrange the submains of each district of equal altitude, so as to keep the several districts disconnected by a stop-cock at their boundary lines. On the adoption of either plan, provision should be made, in case of fire, for changing by some simple movement, the low to the high pressure in a few moments.

The above objections to a high pressure are, we think, not of serious import, and may be disregarded without running much risk of being put at some future time to an expense not calculated for. The application of a few weighted cocks, if they should be found necessary and efficient, would be trivial. Subsidiary Reservoirs would be more expensive, but they would be small, and the steepness of the streets would be favorable to their construction.

The value of water works to a city for the extinguishment of fires, is only secondary to that of supplying its inhabitants with one of the greatest luxuries and necessities of life; and in Quebec this branch of their usefulness seems to me to be of equal importance to the other.

Recent calamities must have convinced the least reflecting, that water, in some form or other, ought to be introduced into the city. A fire, raging on the higher and rocky parts of the city, is a most appalling spectacle; and it is, indeed, painful to witness the expenditure of labor by man and horse, in dragging up the water for the engines on such occasions. This process of supplying water for fires is now necessary, because the wells are inadequate to a full supply, if the conflagration continues any length of time.

In contrast to such a mode of supply, it may be stated, that the proposed conduit from the St. Charles at Lorette, would be sufficient to fill the seven hundred and sixty wells mentioned in the next table, to the average depth of 4.75 feet, more than ten times every twenty-four hours; supposing there was no reservoir in reserve, such as that proposed on the Ursuline Nuns Lot, which of itself would fill the same wells to the same depth more than thirty times, calling their average diameter four feet.

By that account (dated Dec. 20th, 1841,) there were in all the Wards 950 wells. In 760 of them the depth of water is given.

Below in a tabular form is given, the total number, the number measured, and the average depth of water of the wells for each Ward.

	Total No. of Wells.	No. of Wells measured.	Average Depth of Water.
St. Lewis Ward	170	153	4.80 feet.
Palace "	103	98	3.83 "
St. John's "	448	402	4.93 "
St. Roch's "	196	86	4.91 "
St. Peter's "	22	12	5.33 "
Champlain "	11	9	2.93 "
Total,	950	760	Av. depth of the 760 wells } 4.75 "

The following notes, descriptive of the wells, are given at the close of the list:

NOTE 1. The wells in Champlain and St. Peter's Ward, principally rise and fall with the tide.

NOTE 2. The wells in St. Roch's Ward are mostly made to keep the water out of the cellars, therefore very few people use them; but there are some good wells in St. Valier street, principally in the tanneries.

The following statements concerning the effect of jets issuing from mains, submains, fire plugs, &c., to be used in cases of fire, show that great advantages would arise from the introduction of water under a head so great as that proposed.

It was stated by Mr. Anderson, before a Committee of Parliament, that a three quarter inch jet of water from a six inch

main, under a pressure of one hundred and ten feet, rose in the day time fifty-seven feet high, and discharged seventy-eight gallons a minute. In the night it rose sixty-four feet, and discharged ninety-nine gallons a minute. With two jets of three quarters inch, playing at once, the water rose by day fifty-six feet, and threw seventy-eight gallons a minute. In the night, the two jets rose sixty-two feet, and threw eighty-seven gallons. At a pressure of forty-six feet, one jet rose by day, twenty-four feet, and discharged thirty gallons. In the night, it rose twenty-eight feet, and discharged thirty-five gallons. With the same head, two jets rose by day twenty feet high, and delivered twenty-nine gallons. In the night, they rose twenty-five feet, and delivered thirty gallons per minute.

The above experiments exhibit the effect produced on the pressure by the tenants drawing their water during the day.

"At Philadelphia, the water will rise from a hose attached to a fire plug in the street, at the extreme point of delivery during the night, to the height of about forty-five to fifty feet; during the day, when the consumption of water is very great, twenty to thirty feet." Head of water in this case was probably not far from one hundred feet.

Mr. Quick, of the Southwark Water Works, London, stated before the Committee of Parliament, that the time of connecting a hose to the pipes "need be nothing like a minute"—that a jet given off from a twenty-inch main, under a head of one hundred and twenty-feet, would be eighty feet—and that a three inch main, would give, under the same head, a jet forty feet, which would be equivalent to keeping a power of one engine and twenty men in readiness at every door, to act at one minute's notice in case of fire.

From a series of experiments made at the same works, and given in T. Hawksley's evidence, we learn that a seven-eighths inch jet rose fifty feet from the end of a forty-feet hose, attached to a stand pipe of $2\frac{1}{4}$ inches, the water passing from a large main, with a pressure of one hundred and twenty feet on it, through 1750 feet of 15 inch pipe, 600 feet of 12 inch, 1500 feet of 9 inch, and 2400 feet of 7 inch, in all 16,500 feet of pipe. The same size jet at the end of a hose 160 feet long, attached to the same stand pipe, train of pipes and head of

water, rose to a height of forty feet, or one third of the head due to the pressure of water at the origin of the train of pipes.

Another experiment on the same series of pipes, in which five seven-eighths inch jets issuing from as many *forty-foot hoses* and *stand pipes*, and under the same pressure, rose 30 feet high. Mr. Hawksley, in his evidence, gave his opinion, that, as a general rule, a jet issuing from the mains, as usually laid in the streets of cities, would rise to half the height due to the pressure.

The above statements seem to be corroborated by the account we have of one of the highest jets d'eau in the world, at Cassal, in Germany, where a jet of 12 inches diameter, rises 250 feet, under a head of 500 feet.

The highest jet d'eau in the world is that at Chatsworth, which Mr. Paxton had erected, or was erecting in 1844, for the duke of Devonshire. The jet was calculated to rise 280 feet, under a pressure due to a fountain head of 381 feet, the water passing through a pipe 2621 feet long. A jet d'eau, nearly, if not quite as high as this, may be expected at Quebec, should the work now proposed be adopted.

The experiments also show that the fire plugs should be near each other. It is usual in some towns to place them about 300 feet apart, but they should be nearer, and at about half that distance.

In considering the details of the distribution, an important question arises in regard to the material to be used for the service pipes. A proper and convenient material, which at the same time will not be of high cost, is still a desideratum. Lead has hitherto been much used, on account of its plastic nature, which is well calculated for the purpose, but its poisonous quality, so thoroughly proved by the investigation of Professor Silliman, (given in the Appendix,) wholly unfits it, in its unprotected form, for such an application; and should never be hereafter applied to such a use. It is doubtful whether the process of tinning the inside will make it safe. I have the opinion of Professor Silliman to that effect; he recommends either drawn iron, block tin, or tinned copper. The drawn wrought tubes appear to be at the present time in general use in England. Glass has been proposed, but the difficulty of making the joints elastic, and securing it from accident when laid, are great objections to its use.

Besides the usual application, for domestic purposes, for extinguishing fires, and cleansing of side walks and streets, the introduction of water into large towns is, in modern times, much valued for its beneficial effect in scouring the private and public drains; carrying off the debris of houses, and other filth, so often the cause of nuisances, and maladies in families and neighborhoods.

To the uses enumerated, may be added that for manufacturing purposes, which is not to be overlooked as a source of profit. The use of water, however, in this form, depends much upon the cheapness of the supply. I would suggest, for future consideration, the application of the surplus water for mill uses, at a comparative low rate, so long as it should not interfere with the domestic tenant.

ESTIMATE OF COST OF THE LORETTE LINE OF AQUEDUCT.

Length of surveyed line, from Freeman's Dam to the Ursuline Nun's Lot, at Station 12 $\frac{1}{2}$, 41,784 feet, or 7.91 miles.

Length of cast iron conduit, from Station 118 to Station 12 $\frac{1}{2}$, 40,705 feet, or 7.71 miles.

Fall from the surface of the River St. Charles, above Freeman's Dam, or from the level of the proposed Reservoir, at Station 118, to the level of the proposed Distributing Reservoir, on the Ursuline Nun's Lot, is 114.60 feet.

Diameter of proposed cast iron conduit, 18 inches.

The cast iron conduit has been computed from Prony's Formula, using the distance and fall from Station 118 to the Ursuline Nun's Lot, supposing the inside diameter of the pipe to be uniform throughout its length. But in practice, both the internal area and thickness of the pipe should be varied, the area to be increased, and the thickness of metal diminished along the upper or higher parts of the line, especially above the level of the Distributing Reservoir, at the Lorette end of the pipe. The pipe, when enlarged, would, in theory, discharge more water than if kept of uniform section; but there may be accumulations of rust, &c. in the pipe, that would, on the other hand, reduce the discharge to what we have supposed, viz. 480,000 cubic feet in twenty-four hours. The

thickness of the metal allowed in the estimate is $1\frac{1}{4}$ inch, which is the same as the maximum thickness of the country main which conveys the water to the city of Edinburgh. And it is from this example of one of the most original and celebrated works of the kind in Europe, and where the head above the lowest place in the conduit is 350 feet,* that we have proposed this thickness; which it must be allowed, seems a large allowance for strength, or for any decomposition of the outward or inward surface it may be subjected to. For the thickness of pipe required to sustain simply the pressure arising in this case from the quiescent head of water, is comparatively of little consequence in a pipe of this thickness. It is customary

* In a published account of these Water Works, dated Edinburgh, October 19, 1825, as given in a Report made by a Committee of the Board of Aldermen of the city of New York, dated December 28, 1831, we find the following account, under the general head of "Aqueduct Pipe:"

"The aqueduct which conveys the water from the Fountain-head to Edinburgh is about nine miles long, reckoning to Queen street. The elevation of the stone cistern, in the Fountain-head, where the aqueduct pipe begins, is as follows:

"Above the sea at Leith,	564
"Above Prince's street, at the Mound,	360
"Above Reservoir at Heriot's Hospital,	270
"Above do. Castlehill,	230
Above the lowest point to which the pipe descends in its course, namely, at Libberton Dams,	
	350

"The distance from the Fountain-head to the Castlehill Reservoir, in a direct line, is six and a quarter miles; by the line of development, or that which the pipe follows, it is nearly eight and a half miles.

"From Heriot's grounds a branch pipe passes off eastward to supply the southern districts of the town, and another comes up to the Reservoir on the west side of the hospital. A third ascends from the mouth of the tunnel along the side of the Castlehill to the Reservoir there; and various branches pass off to other parts of the town.

"It is to be observed, that a pipe coming from the Reservoirs at Heriot's Green, or the Castlehill, will carry the water no higher than the level of these Reservoirs, but a branch from the main pipe has the pressure of the Fountain-head behind it, and easily makes the water ascend, not only to the top of the highest tenements in the town, but even to the upper flat of the barracks in the castle, which are still nearly one hundred feet below Crawley Spring.

"The pipes which compose the Aqueduct, vary from twenty to fifteen inches diameter, are in lengths of nine feet, and are joined by spigot and faucet.

"The pipes were all proved before they were laid, by being made to bear a pressure equal to that of a column of from three hundred to eight hundred feet of water.

"It begins with pipes of twenty inches interior diameter, and gradually diminishes to a size of fifteen inches.

"It may be proper to mention, that the aqueduct pipe is always covered with three feet of soil, or more, to keep it out of the reach of frosts and agricultural operations. That where it is laid at a depth not exceeding twelve or fifteen feet, it is simply covered with earth, but where the depth much exceeds this, a tunnel of six feet in height, with shafts for descending, has generally been built over it, that access might be had to the pipe afterwards, for repairs, without much digging. There is a tunnel of this sort, about a mile long, across the ridge at Milton Mill."

in fixing the thickness of the pipe, to neglect the consideration of pressure, and only provide for other strains it may be liable to, and for the corrosion of the metal.

In the following estimate the measures of quantities have been kept purposely of the same denomination; for instance, cubic feet for cubic yards; lineal feet for lineal yards, &c., so that they may more readily be converted into other local measures.

ESTIMATE OF THE LINE OF AQUEDUCT.

[illegible]

Conduit from Receiving Well to Subsiding Reservoir.

Excavation	Costs from accounting	Costs from accounting from a continuing account.		
Excavation	26,686	133 43	133 43	

Conduit from Receiving Well to Subsiding Reservoir.

Excavation	26,686	"	133 43	
Hydraulic stone masonry	13,528	"	2,705 60	
Do. brick	1,308	"	392 40	
Puddled earth	14,900	"	74 50	
Heading and wing walls, &c. at subsiding reservoir			54 30	.. 3,360 23
<i>Subsiding Reservoir, Waste-Weir, and Pipe-Well.</i>				
Excavation for puddle trench under embankment	86,265	"	287 55	
Puddled earth for trench and wall in do.	279,396	"	2,793 96	
Embankment in loose earth	489,483	"	2,447 41	.. 5,528 92
Excavation for waste weir	4,800	"	16 00	
Hydraulic stone masonry for do.	3,810	"	952 50	
Do. brick	266	"	79 80	
Puddled earth for do.	2,976	"	29 76	.. 1,078 06
Excavation for pipe-well and culverts	8,080	"	26 93	
Feeding culvert and heading, in hydraulic masonry	831	"	207 75	
Do. " hydraulic brick masonry	170	"	51 00	
Do. " dry stone	467	"	28 02	
Do. " pavement	119	"	3 57	
Hydraulic stone masonry for pipe wells	6,894	"	1,723 50	
Do. " " discharging culvert	1,579	"	324 75	
Do. brick " outside "	560	"	168 00	
Do. stone " " "	2,187	"	437 40	
Pavement	120	"	7 20	
Earth work for drain " " "	8,000	"	26 66	
Puddled earth for pipe wells and culverts	11,391	"	113 91	
House to cover pipe wells		"	265 08	
Roof for entrance to discharging culvert		"	11 90	
Copper strainer and paddle gates for wells		"	500 00	.. 3,965 67
				<u>\$21,150 76</u>

Amount carried over

ESTIMATE—Continued.

	Quantities.	Price, cts.	Dolls.	cts.	Dolls.	cts.
<i>Earth work for Conduit, from Subsiding Reservoir to Distributing Reservoir in Quebec.</i>						
Excavation for pipe from subsiding reservoir to Station 49, at River St. Charles. (See sections on Plate No. 2)	1,219,962	1	6,099	81		
Embankment between the same points, including compacting earth around pipe	974,577	1	4,872	88		
Excavation for pipe from the right bank of the St. Charles to the distributing reservoir at Station 214	157,980	1	789	40		
Embankment, including raising the grade of streets, between same points	124,654	1	934	90		
Extra work for rock-cutting at Lorette church, Station 116	3,200					
Do. " "	2,596					
Do. " " between Station 38 and Bluff, Station 38	37,300					
Do. " " between Station 38 and 214, estimated	43,096					
Enlarging for Pipe Hubs in earth-cutting	4,341	3	1,293	88		
Do. " " rock-cutting	228	20	868	20		
Back filling (in excavation only) not paid for in embankment, calling it same as excavation, notwithstanding the pipe occupies 2½ cubic feet per foot run, of the area of the trench. The trench in deep cutting to be completely filled		100	228	00		
Culvert at George Beider's, Station 93, for large brook. Span 25 feet, length 34½ feet.	1,373,239	1	4,577	43		
Excavation					19,663	50
Concrete for foundation	11,161	1	55	80		
Hydraulic stone masonry	510	17	86	70		
Pavement	15,919	25	3,979	75		
Puddled earth	805	3	24	15		
	10,965	1	89	23		
					4,298	63

Culvert at Station 64, 4 feet span, 30 feet long.
Excavation

Culvert at Station 64, 4 feet span, 30 feet long.

Excavation	2,333	"	17	7 44	
Concrete	108	"	25	18 36	
Hydraulic stone masonry	3,748	"	3	937 00	
Pavement	88	"	1	2 64	
Puddled earth	3,120	"		31 20	996 64
Culvert at Station 60, 4 feet span, 43 feet long					1,109 29
Culvert at Station 54, 4 " 30 "					996 64
Wall for waste-cock and waste-pipe at the St. Charles, say at Station 52, complete					1,233 10
Four stop-cocks on line of pipe from Lorette to Quebec					800 00
Four air-valves " " "					400 00

Stone Bridge over the river St. Charles, at Station 48.

Length, including wings, 249 ft.; width over arches, 26 ft.; at wings, 30 ft.

Coffer dam.	48	Piles.	300	144 00	
Driving guide piles, including timber	70,084	sq. feet.	1	700 64	
Lumber for sheet piling, ribbons, &c.	8,113	"	4	60 84	
Do. caps, &c.	352	Piles.	400	1,408 00	
Driving and repairing sheet piling	36	Caps.	150	54 00	
Preparing and placing caps				50 00	
Do. " ribbons	1,192	lbs.	8	95 36	
Iron bolts for ribbons	2,785	"	6	167 10	
Tie bolts	7,040	Cub. ft.	4	52 80	
Excavation within coffer dam	29,920	"	1	299 20	
Filling coffer dam with clay puddle				100 00	
Labor, fitting tie-bolts, making culvert, &c.					
Total cost of one coffer dam				3,131 94	
Three others required, of same cost				9,395 83	
Amounts carried over				12,527 76	50,578 56

ESTIMATE—Continued.

		Amount brought over		Price, etc.		Dolls.		cts.	
<i>Distribution in the City.</i>									
Laying 14-inch pipe in rocky streets									
Do. 12		940	feet.	320	3,008	00			
Do. 10		1,720	"	190	3,268	00			
Do. 8		6,510	"	165	10,741	50			
Do. 6		4,710	"	135	6,358	50			
Do. 4		8,100	"	95	7,695	00			
Do. 3		13,852	"	70	9,696	40			
Do. 2		10,938	"	110	12,031	80			
Do. 1		46,131	"	82	37,827	42			
Do. 1/2		39,469	"	52	20,523	88			
Do. 1/4		21,990	"	42	9,235	80			
Do. 1/8		13,178	"	76	10,015	28			
Do. 1/16		20,842	"	46	9,587	32			
35 ⁶⁵ / ₁₀₀ miles of pipe, =									
Fire plugs, one for every 300 feet of pipe		188,380	Plugs.	2000	139,988	90			
14-inch stop cocks		550	Cock.		11,000	00			
6 "		2	"	7500	150	00			
4 "		30	"	3500	1,050	00			
3 "		292	"	2500	7,300	00			
Air valves,		92	"	2000	1,840	00			
Add for extra cost of branch pipes		say			500	00			
Service pipes, based on Boston returns		40	tons.	1000	400	00			
		9,000	services.	1250	112,500	00			
							274,828	90	
Add contingencies, engineering, &c., 8 per cent.									
Total cost of Water Works for <i>Lorette Line</i> , exclusive of the cost of land required for the distributing reservoir							591,720	03	
							47,337	60	
							639,057	63	

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MONTMORENCI LINE OF AQUEDUCT.

This line commences at a point on the right bank of the River Montmorenci, at the head of the Rapids known as the Three Falls, in the Seigniory of Ange-Guardien, about half a mile east of the east line of Beauport Seigniory, and distant about three miles on a straight line from the mouth of the river at the High Falls. The river, at the point of departure, passes through the northern part of a ridge, extending towards Quebec about a mile in a southwesterly direction. This ridge is high, and appears to be the drift formation, composed of sand and gravel, sustaining steep declivities on both sides; that on the south-east, over which the line of survey passes, is much the highest, and for some distance its base is washed by the river in its rapid descent over a bed of primitive rock. Above the Rapids the river appeared to be smooth for about a mile to the by-road coming out from St. Michel; and even above that point a short distance.

The line exhibited by the plan (No. 3,) and profile, (No. 4,) passes along the edge of the rocky shore of the Three Falls, from Station 0 to Station 3; but the conduit would be laid down further in on the land at the base of the steep side of the ridge, where it would probably have a foundation on the rock, and be secure from the action of the river in freshets. At Station 3, a short tunnel through rock, or a deep cut might be required to avoid making a bad curve in the conduit. From Station 8 the line follows the side hill, to Station 25. Opposite Station 9, or a little above, the water of the river at the time of the survey was 57.31 feet below the level of smooth water, or Station 0, at the head of the Rapids; and opposite Station 18, it was found to be 88.94 feet below. Along this part of the route the rock is not indicated, but the steepness and height of the slope, together with the looseness of the soil would require the conduit to be buried extra deep in some places, to guard against its being injured by slides.

To avoid delay in clearing a line through the thick forest, the survey was diverted at Station 28 from its proper course, along the side hill, and carried along the cart path to Station 40. By doing this the line is no doubt lengthened, and the

cutting increased; but not to an extent to affect the estimate materially.

From Station 40, emerging from the forest, the line takes a new and direct course towards Quebec; passing across level cultivated fields, leaving the three houses of Lamotte, Boutet, and Dubriel, on the St. Michel road, seven chains to the left. At Station 46, the surface of the country begins to decline, compelling the use of pipes of pressure for the remainder of the way to Quebec. It is proposed to locate here a Subsiding Reservoir into which the water of the Montmorenci should be conveyed by the means best adapted for the purpose.

The works required for the line thus far described would be, a low dam of cut stone masonry placed across the Montmorenci, at the head of the Rapids at Station 3, with a length estimated at one hundred and twenty feet, and from four to six feet high above its foundation on the rock, supposed to extend across under the river.

The Receiving Well, or Fountain Head Chamber, to be of hydraulic stone masonry, placed in connection with the south end of the dam, over an excavated pit in the rock on the shore, where it would be well protected from the violence of freshets, by the projecting rocky point immediately above it. Besides the natural defence, there would be a heavy protecting wall, both above and below the dam.

At the chamber, the conduit, whatever its form, would have its origin; and from thence be constructed on or near the surveyed line, as far as Station 25, where a new line should be taken more direct than that of the survey, represented on the plan, as passing along the cart path in the woods; the new line would unite again with the line run, at or near the proposed Subsiding Reservoir, at Station 46. But for present purposes we have assumed the distance by the new line, to be the same as that actually measured, notwithstanding it is quite certain that a shorter route would be adopted.

On the profile of the route, (No. 4,) the two parallel lines following the surface of the ground, represent the top and bottom of an aqueduct, so large that it would be possible to examine it inside at any time by closing the gate at the receiving well; or by wading through it without shutting off the water. The least dimensions that could be given to a conduit to allow of its

being thus examined, and repaired, if necessary, without disturbing the soil over it, has been fixed at five feet for the height, with a width of three feet at the spring of a semicircular arch of eighteen inches radius; and two feet at the spring of the invert at the bottom — all inside measures.

Such an aqueduct would be capable of discharging at Station 36, the termination of the first slope (calling the fall to that point 13.24 feet) 40.52 cubic feet per second when running full without pressure. This quantity is more than seven times that required for Quebec with 100,000 inhabitants. Of course, the conduit below, from Station 36 to 42, and on to 46 at the Subsiding Reservoir, would be much more capable of conveying the same quantity of water, because the inclination of the slope is greater. An Aqueduct so constructed, would be capable of turning into the valley of the River Beauport a large amount of water — which might be very conveniently used, in its descent of 470 feet, to the tide water of the St. Lawrence, for manufacturing purposes, and would resemble precisely in this respect, the Shaw's Water Works at Greenock, Scotland. There the fall down to the Clyde is 513 feet, and the water, besides its use for supplying the inhabitants, drives two lines of mills in its descent, through separate districts of the town; one line consisting of eighteen, the other of nineteen mills. The annual available water of these Works is stated to be 700,000,000 cubic feet per year, including the supply to the town. The Aqueduct under consideration would discharge in a year 526,400,000 cubic feet more than the Greenock supply, calling the discharge only seven times as much as Quebec would require, as before stated.

The Aqueduct or Conduit above considered is not admitted into the estimate which follows, as its construction would probably depend upon some such consideration as that just mentioned. Its length would be, if executed on the line surveyed, 15,306 feet, or 2.90 miles; and it would cost, constructed on the same line, \$5.06 per foot run, or \$77,448 for the whole distance, without including the works at either extremity. Much of its masonry might be composed of the stratified limestone in the vicinity, so well calculated for such a structure.

The conduit adopted in the estimate would be of brick, of a cylindrical form, laid in hydraulic mortar, two bricks or eight

inches thick. Its interior diameter to be 1.80 feet—to be bedded in earth out of the reach of frosts. It would have one uniform slope from Station 0 to 46, and would probably be located along the side hill south of the surveyed line from Station 28 to 40. The total fall to the surface of the Subsiding Reservoir at Station 46, would be 61.24 feet, and the distance allowed to be the same as that of the survey, viz. 15,306 feet.

This conduit being small like a cast iron pipe, could not be examined or repaired, otherwise than by the usual process of uncovering it. The mean velocity of the water as it would flow by the force of gravity alone, would be 4.20 feet per second, a velocity sufficient to carry along broken stone like road metal (*Pierres cassées, silex*), whether the pipe was full or half full of water. We ought not, therefore, to anticipate any obstruction from sand or even coarse gravel and pebbles. Its discharge when running half full would be just sufficient to supply Quebec with the quantity of water proposed, viz. 480,000 cubic feet in twenty-four hours. When running full without hydraulic pressure from a head of water at its origin, the discharge would be just double, or very nearly double that quantity.

Cast iron pipes could be substituted for the conduit on this division of the line; they would be better on some accounts, but would cost more if possessing the same capacity of discharge. A cast iron pipe just sufficient to carry the supply of 5.55 cubic feet a second, from Three Falls to the Subsiding Reservoir, would have a diameter of 1.40 feet, and if it extended the whole distance from Three Falls to the Distributing Reservoir in Quebec, its diameter would be 1.48 feet; the distance being 52,153 feet, or 9.88 miles, and the fall 157.24 feet. The diameter of the pipe proposed in the estimate leading from the Subsiding Reservoir, at Station 47, to the Distributing Reservoir in the city, is 1.52 feet; calling the fall 96 feet, and the distance 36,374 feet, or 6.89 miles.

The position of the Subsiding Reservoir, in section, is seen on the profile, (No. 4,) extending between Sections 46 and 47, a distance of 473 feet. The area of the reservoir at high water level would be $450 \times 584 = 262,800$ square feet, or 6.03 acres. The cubic contents, when filled eight feet deep to high water level, neglecting the parts below the depth of eight feet,

would be 1,972,779 cubic feet, or 4.11 days' supply for the city. The appendages to this reservoir have been assumed as the same in form and cost as those at Lorette.

From the Subsiding Reservoir the cast iron conduit of pressure would follow with the line of the survey, crossing the St. Michel road at Mr. Jones's farm, passing between his house and barn, and over the flat cultivated fields, and through two patches of wood, crossing the Beauport and St. Michel road, half a mile south of Belanger's Cross. The line thence continues across a small brook to the western extremity of a swell of ground, which, with indications of rock, is too high to allow the line to pass in a straight course from the Subsiding Reservoir to Quebec. From the point of this hill the line is deflected more directly towards the city, and passes down the hill through Edward Clouette's garden, and over the smooth fields south of his house, to the River Beauport, twenty-two chains north of Dr. Racey's isolated farm-house. It thence, passing three chains west of that house on the same direct course, strikes that remarkable boulder rock, located on the high crest of the steep side hill which descends to the Beauport turnpike, between the Ruisseau la Topiere and the River Beauport.

At this point we find the fall from the Subsiding Reservoir's high water level, is but half the whole descent to high water of spring tides; consequently there would not be the same pressure on the pipes here, that there would be at the same distance from the city on the Lorette line — for on that line it is 6.15 miles from the city to where the same height is attained at the boulder, only 4.03 miles from the city.

From the boulder the line continues on the same general course, passing at Station 84 on the brow of the deep ravine, which the La Topiere has excavated in the soft shale rock; and at Station 89, passes two or three chains east of Mr. Methot's house and nail factory; crossing La Topiere brook and valley twice before passing through the premises of Messrs. Richardson and Clackmire. At this point the line enters and follows the Beauport turnpike to the toll-house at Station 107; thence along the site of the old road to the left bank of the River St. Charles, at the north abutment of the Old Dorchester Bridge, at Station 108.

A better route might be found to avoid the inconvenience

and expense of crossing La Topiere brook so often, by diverging at Station 88, passing across the brook between the two lower mills and descending the fields to the wood and brook valley in rear of Richardson and Clackmire's houses, thence across the estate of Dr. Douglass, entering the turnpike, near Station 99, twenty chains nearer the city than the other line does.

In crossing the River St. Charles, just below the site of the Old Dorchester Bridge, the same general course the line has from Station 107 to 108, is kept until we reach the right bank at low water mark; provided the pipe is carried under the channel of the river. But if a stone bridge, like that on the Lorette line be adopted, the angle, necessary for turning the pipe up towards Crown street, would be in the channel, as represented by the bend in the line on the plan (No. 3,) about one chain short of the abovementioned point at low water mark. Should Crown street not be extended as an improvement already designed, and there should be objection to laying the pipe on the flats, the line might be extended to near high water mark, where the angle could be made, and the line deflected through Water street to the surveyed line in Crown street between Station 111 and 112, passing along the east side of the Marine Hospital Yard. Whether the pipe is carried over the river by a bridge, or under the channel, in the way hereafter described, it would pass straight through Crown street, and up the bluff to the Lorette line, at Station 38, foot of St. Claire street. The remainder of the Montmorenci line, from this junction to the Distributing Reservoir, at Station 21½, would coincide in every respect, except in the size of the pipe, with the line from Lorette.

The estimate has been confined to the plan of passing under the St. Charles, instead of the safer, but more expensive structure of a bridge, like the one proposed on the other line. Here, there would be an objection to a stone bridge, arising from its lower position on the river, where it would interfere to some extent with the navigation, there being two or three ship yards, and a few wharves, above the site. Owing to the lowness of the ground on both sides of the river in the vicinity of the crossing place, and the necessity there is of keeping the bridge high, (see the dotted line on the profile) to give free

water way under it, the pipe must ascend to and descend from the bridge, causing two low places in the line, both of which must be provided with waste cocks and their appurtenances; and on the bridge an air valve must be applied. Could Crown street be graded high enough to be on a level with the top of the bridge, to do which would require an embankment over flats of about twenty-five feet high on an average, one of the cocks and the air valve could be dispensed with.

Although there are some objections to a stone bridge at this place, we think they are not of such a character that they could not be obviated, should the city desire such a work for the public accommodation as a highway, in conjunction with the water works, and other improvements in the vicinity. The cost of a bridge of the same dimensions as that on the Lorette line, may be called the same on this — excluding the approaches — which on both lines might be considered chargeable to the public highways, or valuable for other purposes, such as wharves, &c.

The estimate for crossing under the river here, will serve to show that a considerable saving in the cost of the work could be made, by adopting that plan. The question arises, will the pipe be safe, and can it be repaired, should it be practicable to do the work as designed? We think it is practicable to execute the work, and make the repairs afterwards. It is desirable, however, to avoid the many contingencies to which it is exposed, in a work like that of supplying 100,000 inhabitants with an article, to be deprived of which, for a single day, would create an excitement little short of a civil disturbance of a very serious character.

It is proposed, in carrying out this design, of bedding the pipe in the bottom of the river; to build a large, deep well at the angle, alluded to above, as being at low water mark on the city shore of the river. The well would be sunk a few feet below the level of the conduit, as it would be laid under the river. In the well the conduit would be provided with a waste cock and pipe for the discharge at will, from time to time, of the water and any deposits there might be. The well to be furnished with pumps for readily draining it — and covered by a house of brick masonry.

From this well it is proposed to drive a double row of heavy

sheet piling, six feet apart, or less, in the two directions in which the pipe would enter and leave the well. The piles to be jointed, tongued and grooved, and eight or nine inches thick. The use of these piles is twofold; the first is to give facilities for laying down the pipe and repairing it afterwards, as occasion requires; the second, to prevent the conduit from accident, in case a vessel or other heavy body should ground over it.

The well, situated as it would be in the river, exposed to accidents from floating bodies, must be protected; for this purpose, it is proposed to build a wharf about it, connected with the shore on the city side; the wharf to be one hundred feet wide by about two hundred feet long; the sides at right angles with the continuation of Crown Street. Such a wharf would be valuable for a landing place and appendage to the ship-yard, situated on the shore at its base. Should a wooden bridge be built here, the wharf would serve for its south abutment; and (after the flats were filled in, as contemplated, at the foot of Crown Street,) a very desirable avenue would be opened into the city from the Charlesbourg road and Beauport turnpike, supposing the latter was again opened from the Toll House to the site of the Old Dorchester Bridge. In connection with such an improvement, a street might be opened in line with the bridge and turnpike, across the ship-yard and Marine Hospital Grounds into Dorchester Street. Should it be determined, for considerations not connected with the Water Works, to fill in the flats or beach between the wharf and present foot of Crown Street, much of the expense of laying the conduit in the first instance, and afterwards in repairs should they ever be needed, would be saved. The pipe in that case would be turned up from the bottom of the well, to the proper depth under the surface of the street, and would then be accessible at all times. Great care should, however, be taken to consolidate the filling immediately under the conduit, in order to prevent unequal subsidence, and the consequent ruptures of the joints.

The general character of the Montmorenci Line, as to the quality of the soil for trenching and evenness of surface, proves much more favorable than the aspect of the country at first promised; a few places only out of the city were found where rock appeared, or was indicated; and at those places, except at Three Falls, this rock would be easy to quarry, being either

the thin loose stratified limestone, like that seen near the Beauport Church ; or the soft slate formation, like that in the great scarps at the foot of the Montmorenci Falls. The points alluded to are : — At Three Falls, between Stations 0 and 4 — at the road leading from Belanger's Cross to Lamotte's, between Stations 55 and 56, where an open quarry of stratified limestone in Verret's field was crossed by the line : — at the point of the hill through Minville's field from Station 64 to 69, where the loose stratified limerock was indicated, but not seen above the ground, by the numerous small fragment of that rock strewn over the surface : — also on the crest of the Beauport side hill at the Great Boulder, between Station 77 and 80 ; here the soft slate rock might be reached in the deeper cutting, for it shows itself in the sides of the ravine of the brook La Topiere, opposite Station 84. Within the city what rock is found is considered common to both lines.

ESTIMATE OF COST OF THE MONTMORENCI LINE OF AQUEDUCT.

Length of Surveyed Line from Three Falls to the Ursuline Nuns Lot, 52,153 feet or 9.88 miles.

Length of Conduit in masonry from Station 0 to Station 46, at Reservoir of Subsidence, 15,306 feet or 2.90 miles.

Length of Conduit in cast iron, from Station 47 to Station 21½, at the Ursuline Lot, 36,374 feet or 6.89 miles.

Fall from surface of still water above Three Falls, at Station 0, to the surface of the proposed Reservoir of Subsidence, between Station 46 and 47, 61.24 feet.

Fall from surface of Reservoir of Subsidence, to surface of Distributing Reservoir in city, 96.00 feet.

Whole fall from Station 0 at Three Falls to Station 21½, at Distributing Reservoir in city, 157.24 feet.

Whole fall from Station 0 at Three Falls to High Water Spring Tides at Quebec, 487.24 feet.

The dimensions of the cast iron conduit, and the computation relating to the discharge of the conduit in masonry, already noticed, have been, as on the Lorette Line, computed from Prony's Formulæ, using the data given above ; and supposing the iron pipes or conduits in masonry to be of one uniform section throughout their lengths. In other respects, this estimate is governed by the same rules that were adopted for the Lorette Line.

ESTIMATE OF THE MONTMORENCI LINE OF AQUEDUCT.

	Quantities.	Price, cts.	Dolls.	cts.	Dolls.	cts.
<i>Dam at Head of Three Falls.</i>						
Lumber for coffer dam	22,660	sq. ft.	1	226	60	
Iron work for do.	672	lbs.	5	33	60	
Labor on do.				369	00	
Earth filling for do.	4,500	cub. ft.	$\frac{1}{2}$	22	50	
Hydraulic cut stone masonry for dam	3,600	"	25	900	00	
Iron dowels and setting, for crest stones				65	64	
<i>Receiving Well and Walls of Defence.</i>						
Excavation in rock, estimated	7,400	"	4	296	00	
Hydraulic stone masonry for well	3,472	"	25	868	00	
Dry " " " " " " " "	2,192	"	10	219	20	
Dry " " " " " " " "	13,640	"	10	1,364	00	
Puddled earth about well and wing walls	3,008	"	1	30	08	
Embankment	7,520	"	$\frac{1}{2}$	25	07	
Gates for well				107	44	
Iron rack or grating, for culvert admitting the water from the river				45	72	
Strainer of wood for well				15	00	
House to cover well, complete				217	15	
						.. 3,187 66
<i>Aqueduct in masonry from Receiving Well to Subsidizing Reservoir at Station 46</i>						
Grubbing line, 13,200 feet in length	15,306	feet.	225	34,438	50	
Deep cutting in rock near Station 3, extra	4	acres.		800	00	
<i>Subsidizing Reservoir at Stations 46, 47.</i>						
Stone conduit head, &c. same as at Loretto reservoir	56	feet.	800	448	00	
Waste-weir				54	30	
Pipe-weir, culverts, gates, and strainer				1,078	08	
Excavation (less charged to Embankment, &c.) for reservoir	478,728	cub. ft.	$\frac{1}{2}$	3,965	67	
Do. for puddle ditch	66,146	"	$\frac{1}{2}$	2,393	64	
Embankment	487,542	"	$\frac{1}{2}$	330	73	
Puddled earth in embankment	245,027	"	1	2,437	71	
				2,450	27	.. 12,730 38

[illegible][illegible]

Amounts carried over

ESTIMATE — Continued.

	Quantities.	Price, cts.	Dolls.	cts	Dolls.	cts
Excavation for foundation of well . . .	3,836	1	11,673	24	85,436	13
Concrete " . . .	255	17	43	36		
Masonry for well . . .	3,627	25	906	75		
Puddled earth about well . . .	6,755	4	50	65		
Drainage while building the well . . .			30	00		
Underpinning for house over well . . .	224	20	44	80		
House to cover well . . .			105	00		
Pumps for well . . .			100	00		
Waste pipe and waste cock for well . . .			242	00		
			13,234	15		
<i>Wharf to protect Well, 200 feet long, 100 feet wide, viz.</i>						
Excavation for trench walls . . .	13,095	4	65	47		
Trench wall round wharf . . .	11,160	10	1,116	00		
Face wall " . . .	41,384	10	4,138	40		
Stone work for arches over the water pipe . . .	6,090	12	730	80		
Filling in wharf with earth . . .	262,486	4	1,068	64		
Lumber for capsill, &c. round wharf . . .	1,018	10	101	80		
Labor in preparing and placing capsill . . .	505	10	50	50		
					21,405	76
<i>Earth and rock work between Stations 111 and 38, in city.</i>						
Excavation in earth . . .	83,686	4	418	43		
Do. rock . . .	4,716	4	188	64		
Back filling . . .	88,402	4	294	67		
Embankment . . .	1,720	4	12	90		
Enlarging trench for hub of pipes . . .	285	20	57	00		
					971	64

Earth and rock work between Stations 38 and 21½ in city.

Excavation in earth	55,228	cub. ft.	276 14	
Do. in rock	36,085	"	1,262 97	
Enlarging trench for pipe hubs in earth	95	Hubs.	19 00	
Do. " in rock	228	"	228 00	
Back filling	91,313	cub. ft.	304 36	
Damages of all kinds on the country portion of the work				2,090 49
				2,000 00
				111,904 01
				161,500 56

Cost of laying 18-inch cast iron Pipe, exclusive of earth work, from the subsideing reservoir, Station 47, near Lamotte's, to the distributing reservoir, Station 21½, in the city, as per the following estimate of the unit cost of pipe

Cost of laying one Joint of Pipe.

Iron for one joint, 1½ inch thick	2,298 lbs. at 14 cts.	\$34 02
Lead for do.	40½ "	4 "
Yarn for do.		1 82
Labor, fuel, tallow,		18
Transportation of pipes, &c. to mean distance, 2½ miles, at 20 cts. 55		1 17
Total cost of laying one joint	8.50 feet, \$4 44	\$37 74

Cost for the water delivered at the distributing reservoir in the city, exclusive of contingencies, &c.

Distributing reservoir same as for Lorette line

Distribution in the city "

Add contingencies, engineering, &c. 8 per cent.

Total cost of Water Works for *Montmorenci Line*, exclusive of the cost of land required for the distributing reservoir

273,404 57
37,680 88
274,828 90
585,914 35
46,873 15
\$ 632,787 50

The foregoing estimates show the whole cost of introducing a full supply of water for one hundred thousand inhabitants, and distributing it to the present population, to be nearly the same by either route; the difference being \$6270.13, and in favor of the Montmorenci line. There are other considerations of more consequence in favor of that route, than this small difference of cost. For instance, in case a supply double that now contemplated should ever be demanded, the cost of bringing it to the city would be less by about \$17,000 by that line than by the Lorette, on account of the difference of 4321 feet in the length of the pipe from the Subsiding to the Distributing Reservoir, omitting the estimate for earth and rock work, being nearly the same for each. Another consideration that may be mentioned as favorable to the Montmorenci line is, that the water would not pass quite so far through an iron pipe in its course to the city. It would, of course, be somewhat less impregnated with dissolved iron rust, should the water have the effect of corroding the pipe.*

A third consideration is that already mentioned of the value of the surplus water, delivered at or near the Subsiding Reservoir, for mill purposes, which could be used whenever there should be a demand for it. On the other hand, we think that the Lorette line has a decided advantage in the simplicity and safety of the required works, and should we be left to decide on our present information, should choose this source. The fact that the Fountain Head is nearly on a level with a large natural reservoir (Lake St. Charles), which can be made avail-

* The following is copied from a French translation of an English description of the Greenock Water Works, Scotland: — "L'eau destinée à la consommation domestique des habitants, aux raffineries de sucre et autres besoins, devant être pure, est réunie dans des réservoirs disposés à part pour cet objet; on n'y laisse arriver que le moins possible d'eau marécageuse. On a aussi établi un aqueduc séparé pour porter cette eau aux filtres, exactement au-dessus de la ville, où l'on a construit également un réservoir assez étendu pour contenir l'approvisionnement d'un peu plus d'un jour en eau filtrée. Cet aqueduc, qui a quinze pouces pleins en carré, est imperméable à l'eau; il est formé de pierres appareillées avec soin et bien cimentées; il coûte un peu moins que le tiers du prix d'un tuyau de fonte des mêmes dimensions. Partout où la pression n'est pas grande, un conduit de cette espèce est préférable à un tuyau en fonte, attendu que l'eau qui coule sur la pierre est plutôt améliorée que détériorée; il n'en est pas de même avec le fer. Dans cet aqueduc, qui est enfoncé assez profondément en terre pour éviter l'influence des gelées et des grandes chaleurs, on forme des puisards pour le dépôt des sédiments, parce qu'il importe que l'eau, avant d'entrer dans les filtres, soit aussi pure que la nature des choses peut le permettre."

able for equalizing the supply at Lorette during long continued periods of dry or cold weather, produces a certainty that the water need never be cut off by such vicissitudes — while on the Montmorenci no such reservoir exists to our knowledge, within the same distance of the proposed source of the Aqueduct at Three Falls. Still we feel every confidence in the sufficiency of this last named stream, and should the city, for any reason, wish to use its water in preference to that of the St. Charles, it is our opinion that it would be safe to do so.

To complete this work according to the estimates, demands an expenditure of a large capital; and it may be asked, if there is no way to curtail the work to make the expense at the outset, lighter for the citizens or any party who undertake its execution. This, we think, is practicable to a certain extent, but in a degree dependent upon contingencies, to be discovered only by further and more particular investigation. It may be found, on examination, that the Subsiding Reservoir on either line selected could be dispensed with; their chief office being, by checking the motion of the water, to allow it to deposit the heavy particles of floating matter which the river may at times contain, at the origin of the Aqueduct. I am inclined to believe, from what I have been enabled to see, that waters much more highly charged with sediment than either of these streams, are very often allowed to enter the pipes of Distribution in some of the large cities in England or Scotland. The character of the sediment here is probably a sand, coarser or finer according to the violence of the flood, and is not like that produced where the river drains a clayey district.

The city Reservoir could not be permanently dispensed with, but it is possible to do without it for a few years, until the water gets into general use, or until that time when the discharge of the conduit under the pressure of its standard head, shall be equal to the maximum draught of the water-takers during any portion of the day.

Should the water prove pure enough to be drawn directly from the St. Charles at Freeman's Dam, and should we postpone the construction of the Distributing Reservoir in the city, the estimate of cost of the whole work, with the two reservoirs omitted, would stand as follows: —

SECOND ESTIMATE, (LORETTE LINE.)

OMITTING THE SUBSIDING AND DISTRIBUTING RESERVOIRS.

	Quantities.		Price cts.	Dolls.	cts
Dam, abutment, cylindrical conduit, receiving well and apparatus, &c., according to first estimate				7,217	88
Excavation for cast iron pipe, from receiving well to Station 118, including enlarging trench for hubs	47,640	cub. ft.	$\frac{1}{2}$	238	20
Embankment between same points	5,848	"	$\frac{1}{2}$	29	24
Cast iron conduit laid, exclusive of earth work between same points	980	feet.	440	4,302	00
Earth and rock work, including bridge over the St. Charles, culverts, damages, &c. from Station 118 to Station 21 $\frac{1}{2}$ in the city. Per first estimate				79,364	50
Cast iron conduit 18 inches diameter, 1 $\frac{1}{2}$ inches thick, laid, exclusive of earth and rock work between same points. Per first estimate	40,705	"	439	178,694	95
Distribution in the city. Per former estimate				274,928	90
				544,685	87
Contingencies, engineering, &c. 8 pr. ct.				43,574	85
Total cost of water works				\$588,260	52

Conceiving there may be different opinions in regard to the proper thickness for the pipe in the country, a third estimate is given, in which the thickness of metal is supposed to be one inch; the estimate in every other respect remaining the same as the second.

THIRD ESTIMATE, (LORETTE LINE.)

PIPE CALLED ONE INCH THICK.

	Quantities.		Price cts.	Dolls.	cts
Amount of the second estimate, exclusive of the item for the cast iron conduit; contingencies and engineering				361,678	72
Cast iron conduit 18 inches diameter, 1 inch thick, laid, exclusive of earth and rock works, from the receiving well to Station 21 $\frac{1}{2}$ in the city	41,685	feet.	356	149,232	30
				510,911	02
Contingencies, &c. 8 per cent.				40,872	88
Total cost of water works				\$551,783	90

The price of the pipes adopted in the estimates, has been based on information obtained by letter from Mr. Peebles, in Scotland, who was then (March 22, 1848,) paying at the rate of £5 15s. for spigot and faucet pipes, intended for the Quebec Gas Works; he also states the price of freight from the Clyde to Quebec, varied from 9s. to 12s. 10d. per ton. Using these prices, and adding for other probable charges, duties, and allowances, we deemed it perfectly safe to affix the price we have, viz. 1½ cents per pound of iron.

The other prices used in the estimate have been obtained from various sources, most of them from authentic information procured at Quebec, and all are, we trust, sufficiently correct for the general purposes of the investigation.

We are, perhaps, not so well prepared, or so capable of estimating the probable income from the water works as persons more familiar with the wants and habits of the citizens, and who would better know to what extent the water would be wanted for large establishments, such as stables, refineries, distilleries, tanneries, and other manufactories. We may, however, aid in this inquiry by referring to results in other cities, where the circumstances are analogous. It has been for this object that we have taken some pains to introduce in the Appendix, statistical tables relating to various water works in the United States, England and Scotland, (see Appendix, B, C, D, E.) The table (E) relating to Fairmount Water Works, shows the average annual charge to a tenant in Philadelphia, from the first year of supply in 1801, to 1845, using only the numbers given in column 13, to be \$5.67. In New York, for the three years ending May 1, 1847, the average is \$12.94, more than double the maximum annual charge (\$6.23) of the former city, omitting the first year, 1801. In Philadelphia, the usual charge for a house of the common class, appears to be \$5, and in New York, for a house with two stories, \$10; three stories, \$12. In Boston the water works are not completed, and we do not know what the charge for the same class of houses will be; but probably from \$7 to \$8. In England and Scotland the rate varies considerably in the same city; for instance, in London, the range is from 15.47 to 56.14s. per house per annum, or from 3.71 to \$13.47. The mean annual charge made by the five water companies on the

north side of the Thames, comprising the years 1820 and 1827 only, was very nearly 30s. or \$7.20 per house per annum. From these examples, we infer that people living in cities, ordinarily would be willing to pay \$7, and more, for the use of good water; and in the following estimates of income, that sum has been adopted as the average rate, which the tenants at Quebec would be willing to pay.

At page 14 we have assumed the population of the city to be, at the end of thirty years, from the year 1847, 100,000; which is allowing a compound increase of 3.45 per cent. per annum on 36,155, the population of the city in 1847. With this ratio we find there would be at the expiration of five years, from 1847, a population of 40,837; and at the expiration of ten years, 50,754.

Now, assuming no greater proportion of residents as taking the water, than was found to prevail at Philadelphia, that is, one water-taker to $7\frac{1}{3}$ of the population, we get the number entered in Column 3 of the following table; and supposing each taker to pay on an average \$7 per annum for his supply, we get the income entered in Column 4. In the last three columns are shown the interest the income would pay on the capital invested in the works. Column 5 giving the annual rate for the first estimate, Column 6 that for the second, and Column 7 for the third estimate.

INCOME COMPUTED FOR THE LORETTE LINE.

1.	2.	3.	4.	5.	6.	7.
For the year	Actual and assumed population of city	Number of tenants, deduced by dividing the population in Column 2 by $7\frac{1}{3}$	Income to be derived from the Water Works, calling the average charge per tenant equal to \$7.	Rate per cent. computed on the capital, (\$639,057 63,) expended per 1st Estimate, producing the income entered in Column 4.	Rate per cent. computed on the capital, (\$588,260 52,) expended per 2d Estimate, producing the income entered in Column 4.	Rate per cent. computed on the capital, (\$551,783 90,) expended per 3d Estimate, producing the income entered in Column 4.
1847,	36,155	4,930	\$34,510	\$5.40	\$5.86	\$6.25
1852,	42,837	5,841	40,887	6.40	6.95	7.41
1857,	50,754	6,921	48,447	7.58	8.23	8.78

This table shows the gross income, or the value of the benefit to be derived from the works, if executed on the Lorette Line, for the several periods stated, based on the three estimates of cost. From the gross income the charges of management are to be deducted; which in this case must be very light, the work being so simple, and so little liable, as it ought to be, to get out of repair. At Philadelphia, where the water is all pumped for the supply, the charges of *Distribution*, embracing the repairs and cost of protecting the pipes in the city, appear to be (see Appendix, G,) for the average of six years, from 1840 to 1845, inclusive, nearly \$4000 a year; — *Salaries*, averaging, the same years, a little over \$4000; and *Incidentals* \$950 a year. These items, except that of distribution, are of course augmented above what they would be if the supply was furnished simply by gravitation, from some natural source of adequate height, as proposed here.

If, however, we suppose them to be the same at Quebec, in proportion to the number of tenants, the items for the several periods would amount to the following sums:

	1847.	1852.	1857.
Distribution to 4930 tenants, an. expend. =	\$786 03		
Do. " 5841 " " " =		\$931 28	
Do. " 6921 " " " =			\$1103 47
Salaries " 4930 " " " =	808 09		
Do. " 5841 " " " =		957 42	
Do. " 6921 " " " =			1134 44
Incidentals " 4930 " " " =	188 83		
Do. " 5841 " " " =		223 73	
Do. " 6921 " " " =			265 10
Total annual expenses of each year,	\$1,782 95	\$2,112 43	\$2,503 01

Deducting these expenses from the income entered in the 4th Column of the former table, and computing on the balance, or net income, (allowing the charges to be alike on all these estimates) we get the rate per cent. or interest the works would yield, thus:

	Rate for 1st est.	Rate 2d est.	Rate 3d est.
For 1847, net income=\$32,727, yielding an interest of	\$5 12	\$5 56	\$5 93
" 1852, " " = 38,775, " "	6 07	6 59	7 03
" 1857, " " = 45,944, " "	7 19	7 81	8 33

This exhibit of the probable rates of income, depending upon the amount expended, is, we think, impartial, and has for its

support much evidence in the results of other works, where the original projects were much more enveloped with difficulties, and subjected to large expenditures, both at the outset, and in the necessity of afterwards keeping up the supply by artificial means.

In performing the field work on which this report is based, valuable aid was rendered by assistant engineers, Messrs. Alf. Hamel and E. H. Le Gendre, of Quebec. It was our endeavor to make the surveys as full and perfect as circumstances and time would permit. There was but one line on each of the country routes run, and consequently their accuracy has not been tested by second levellings; still, I feel assured, that, if any errors have occurred, they must be trivial. In the city the greater part of the levellings were satisfactorily tested by completing the circuit.

Most respectfully submitted,

GEO. R. BALDWIN.

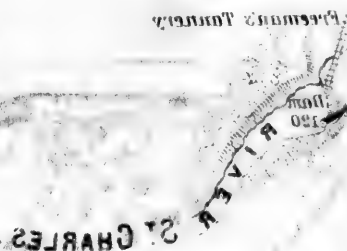
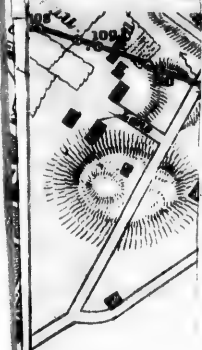
Hon. G. OKILL STUART,

Mayor of the city of Quebec.

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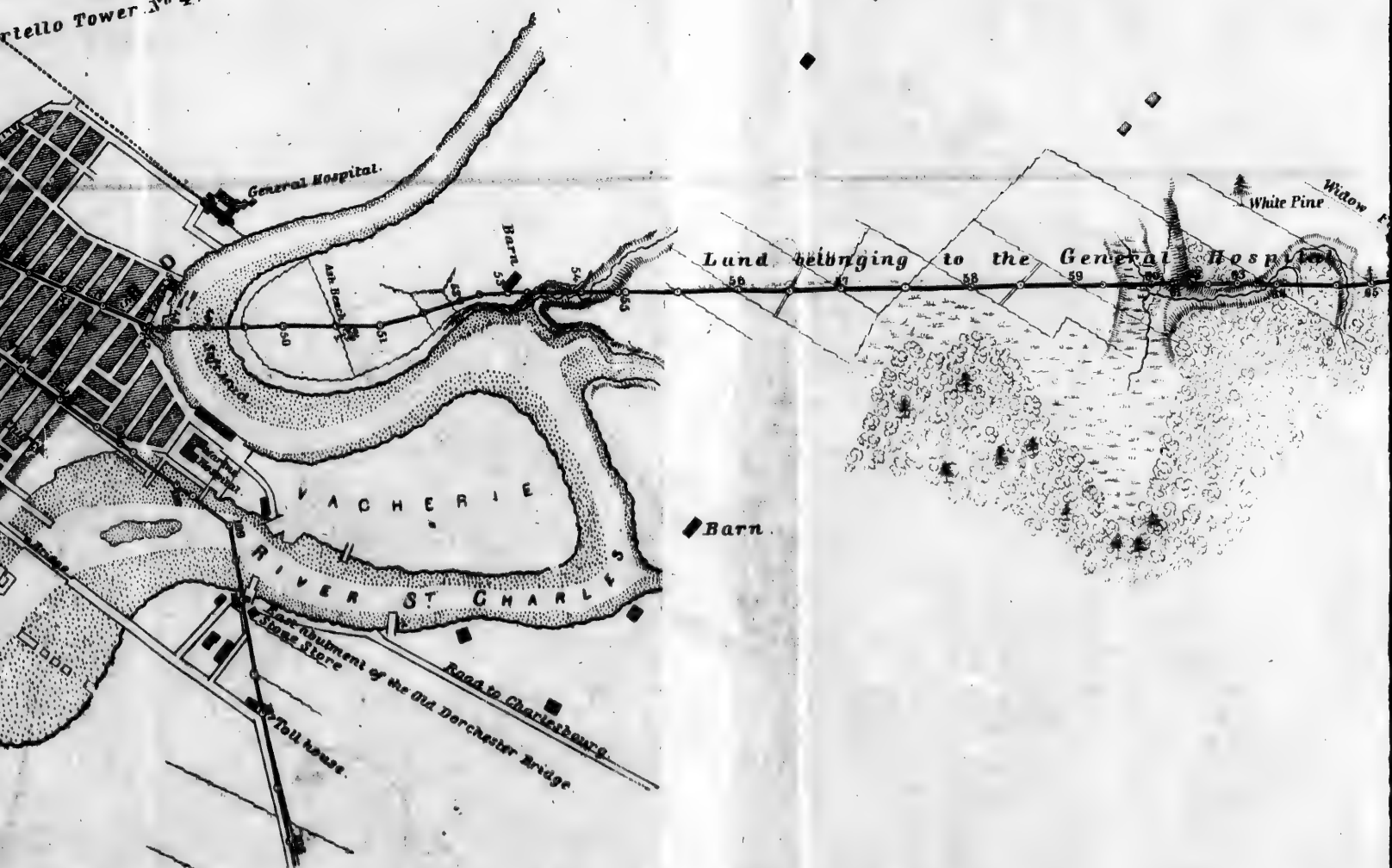
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F I

Artello Tower No 4.



Land belonging to the General Hospital

Barn

White Pine Widow

General Hospital

Remnant of the Old Dorchester Bridge

Road to Charleston

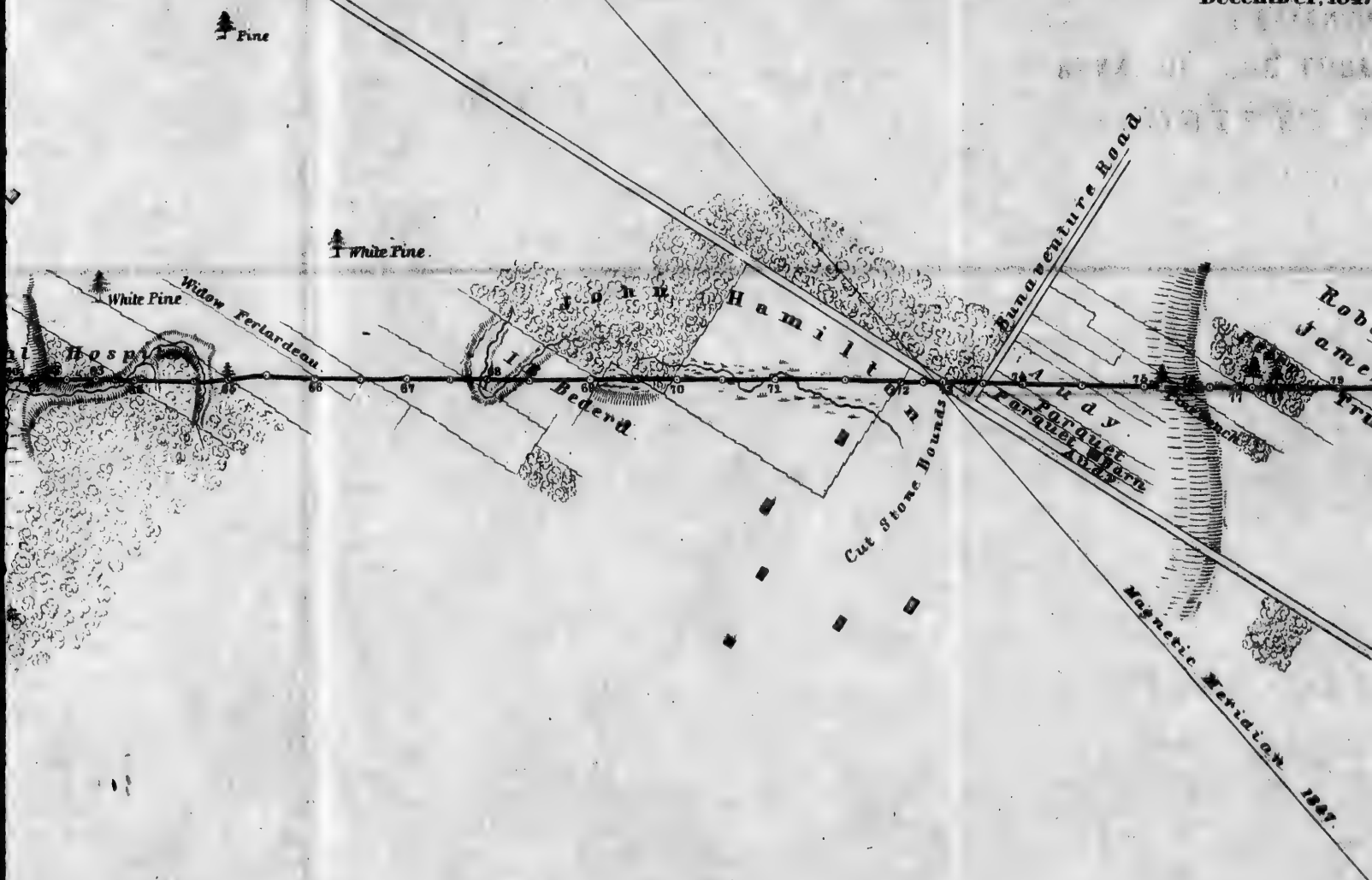
Toll house

VACHERIE RIVER ST CHARLES

QUEBEC W PLAN OF THE LORE EXTENSION

Made
HON. G. ORILL 82

December, 1847

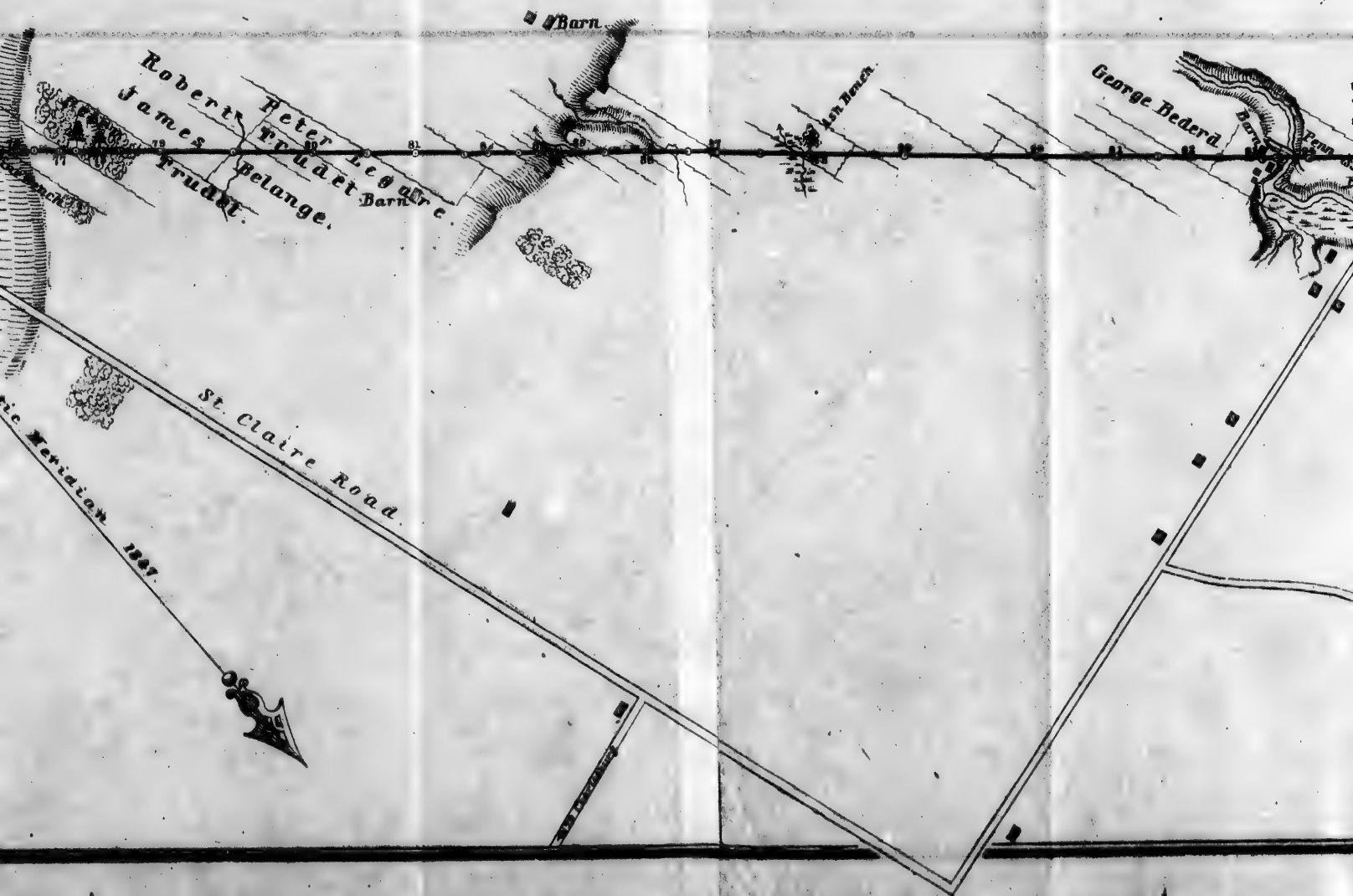
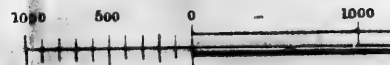


QUEBEC WATER WORKS. OF THE LORETTE LINE OF AQUEDUCT. —AND— EXTENSIONS IN THE CITY.

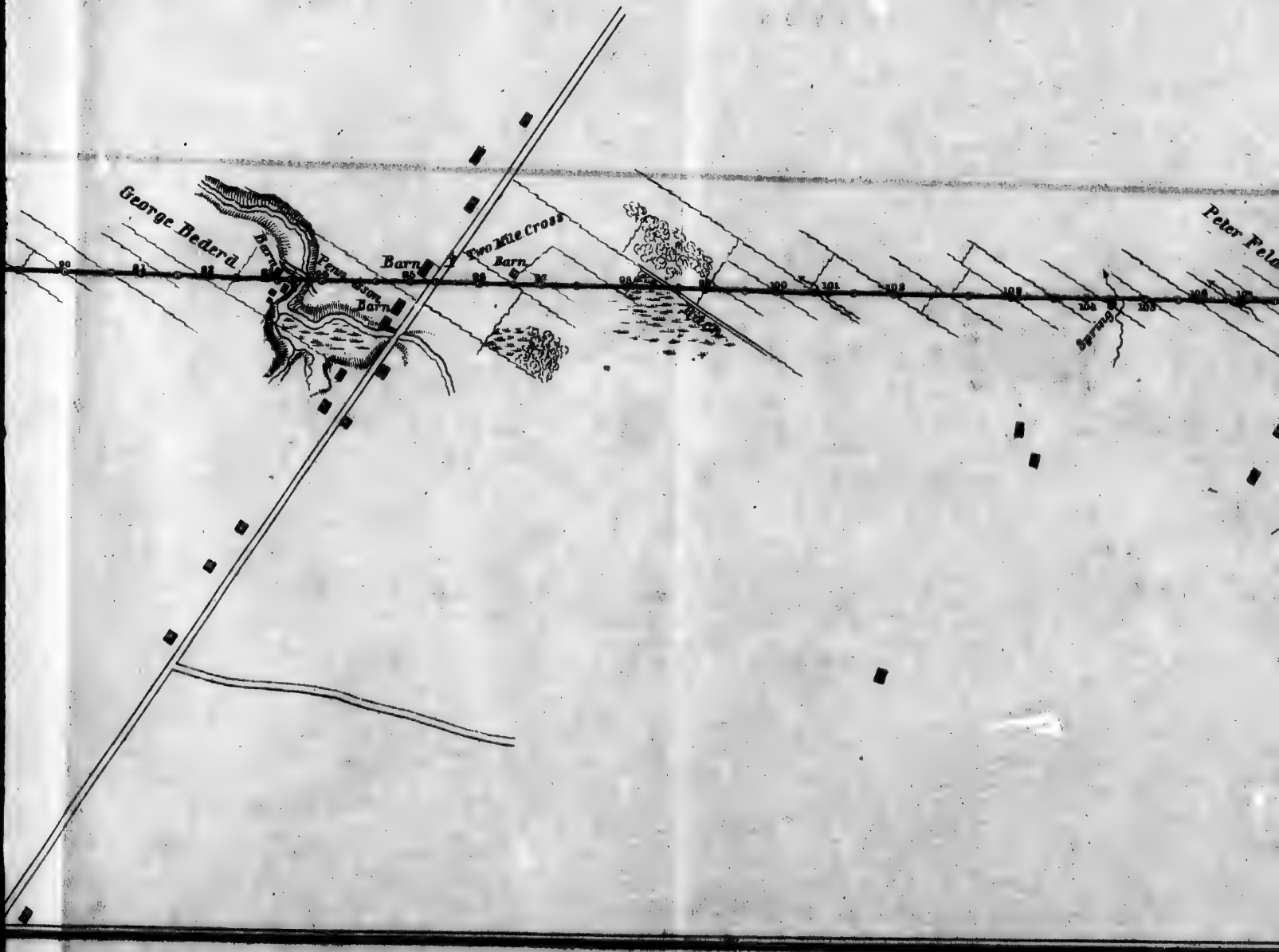
Made by Order of
HON. G. ORILL STUART, MAYOR of QUEBEC.

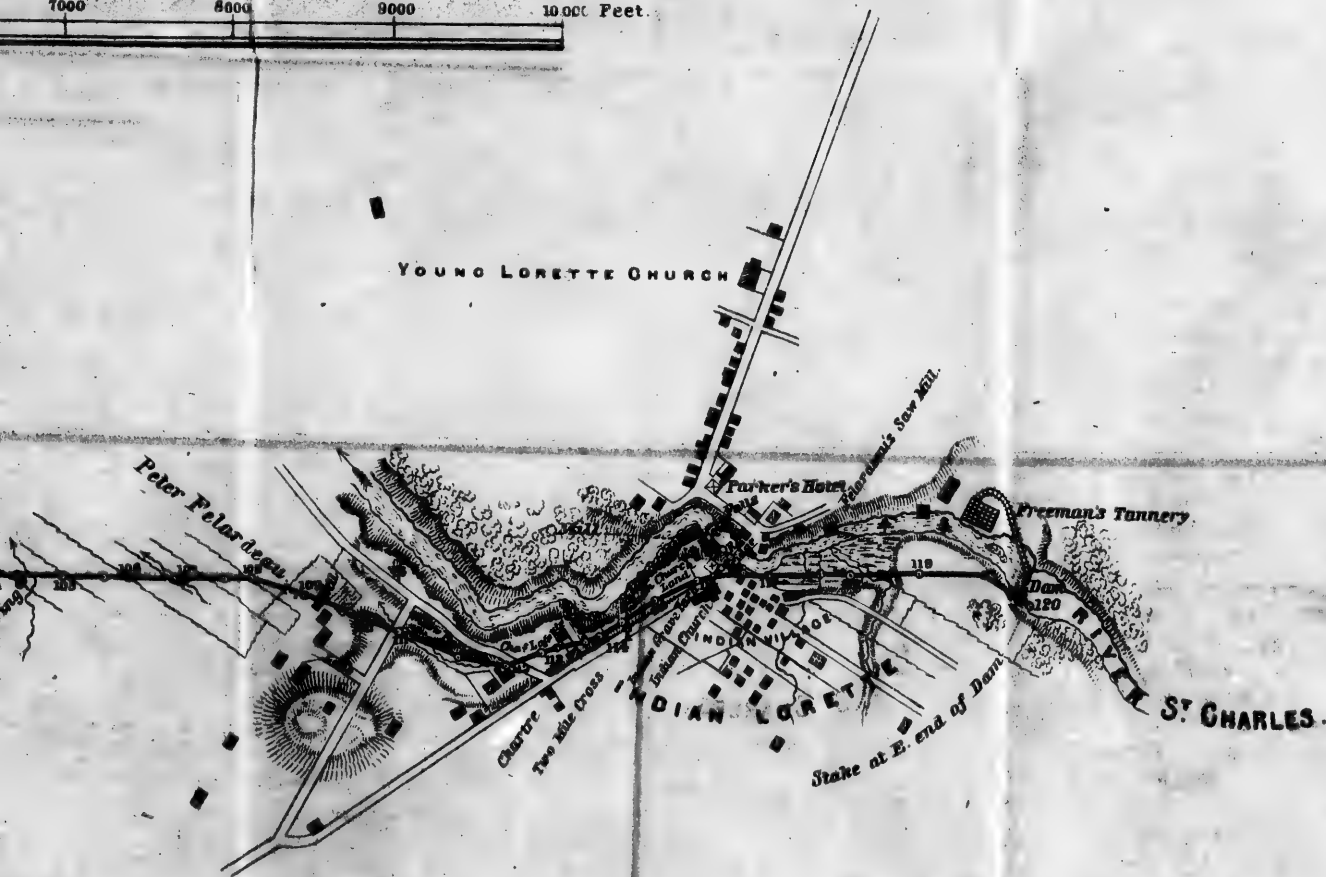
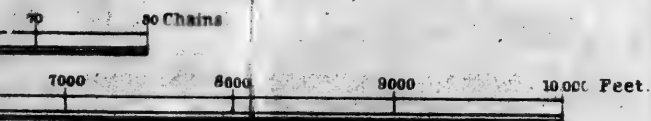
December, 1847. Geo. R. Baldwin, Engineer.

LITH. BY E.W. BOUVÉ Boston.



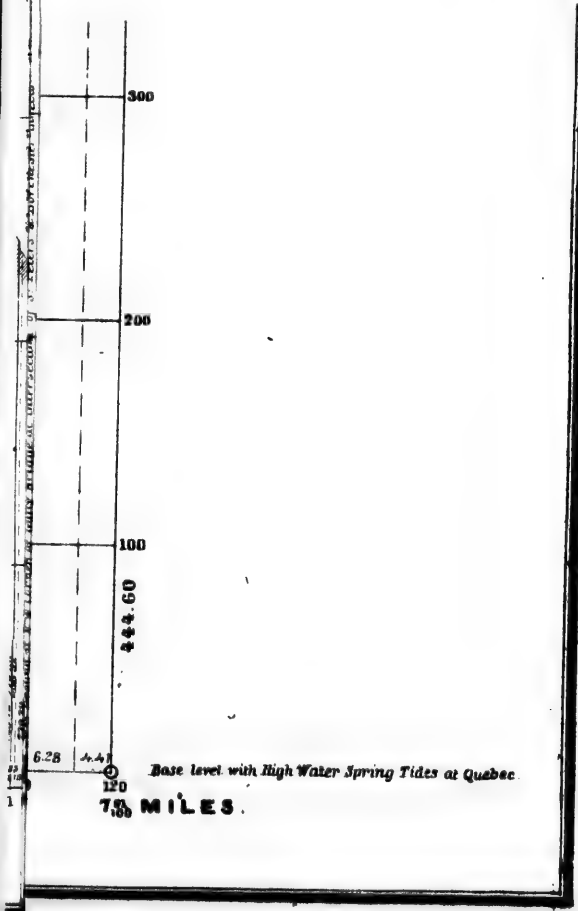
SCALES.





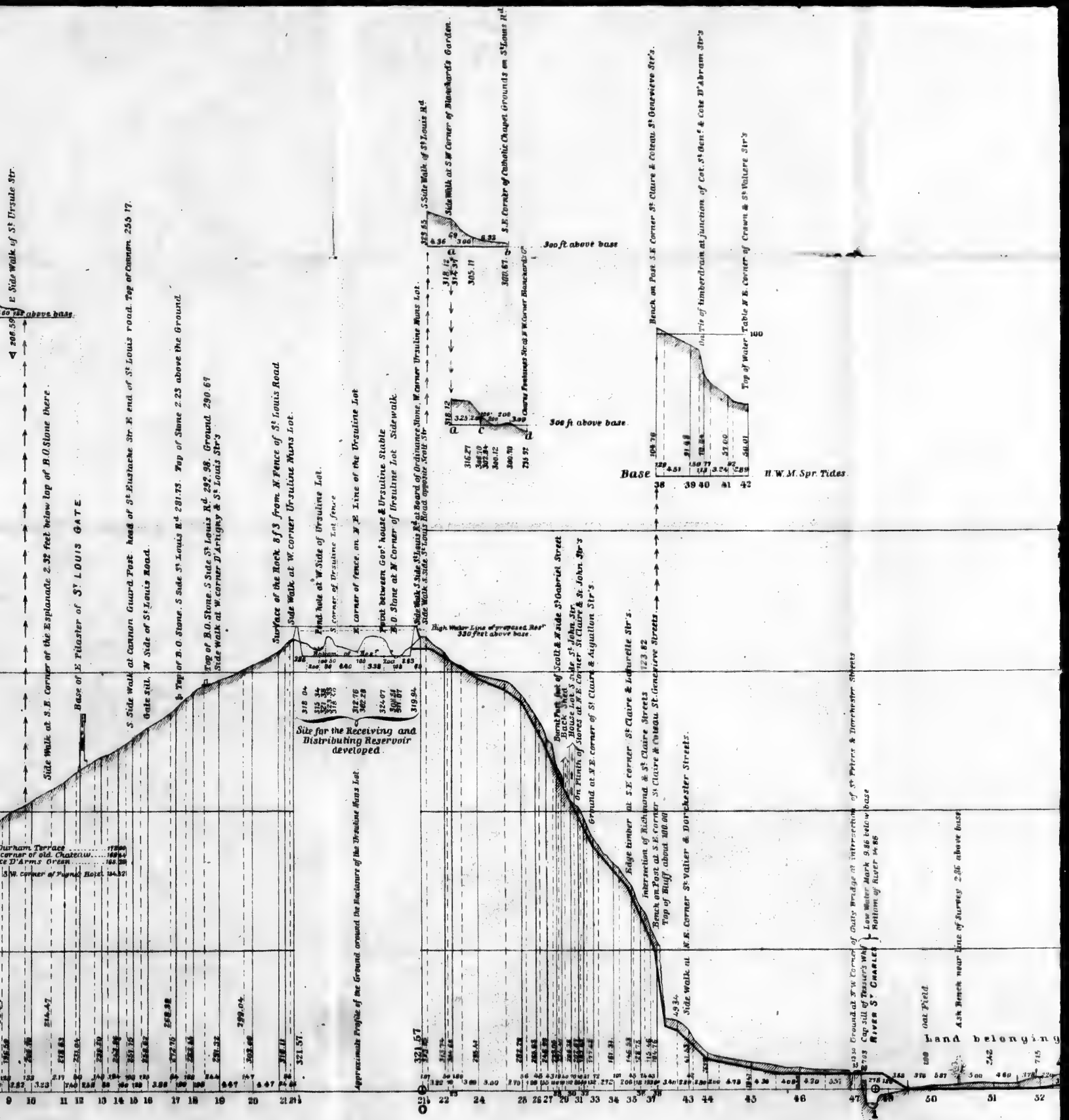
1. WILLIAM J. BROWN is the owner of the premises described in the foregoing plat, and he is the owner of the same for the purpose of the same.

11



Base level with High Water Spring Tides at Quebec.

7.50 MILES.



QUEBEC

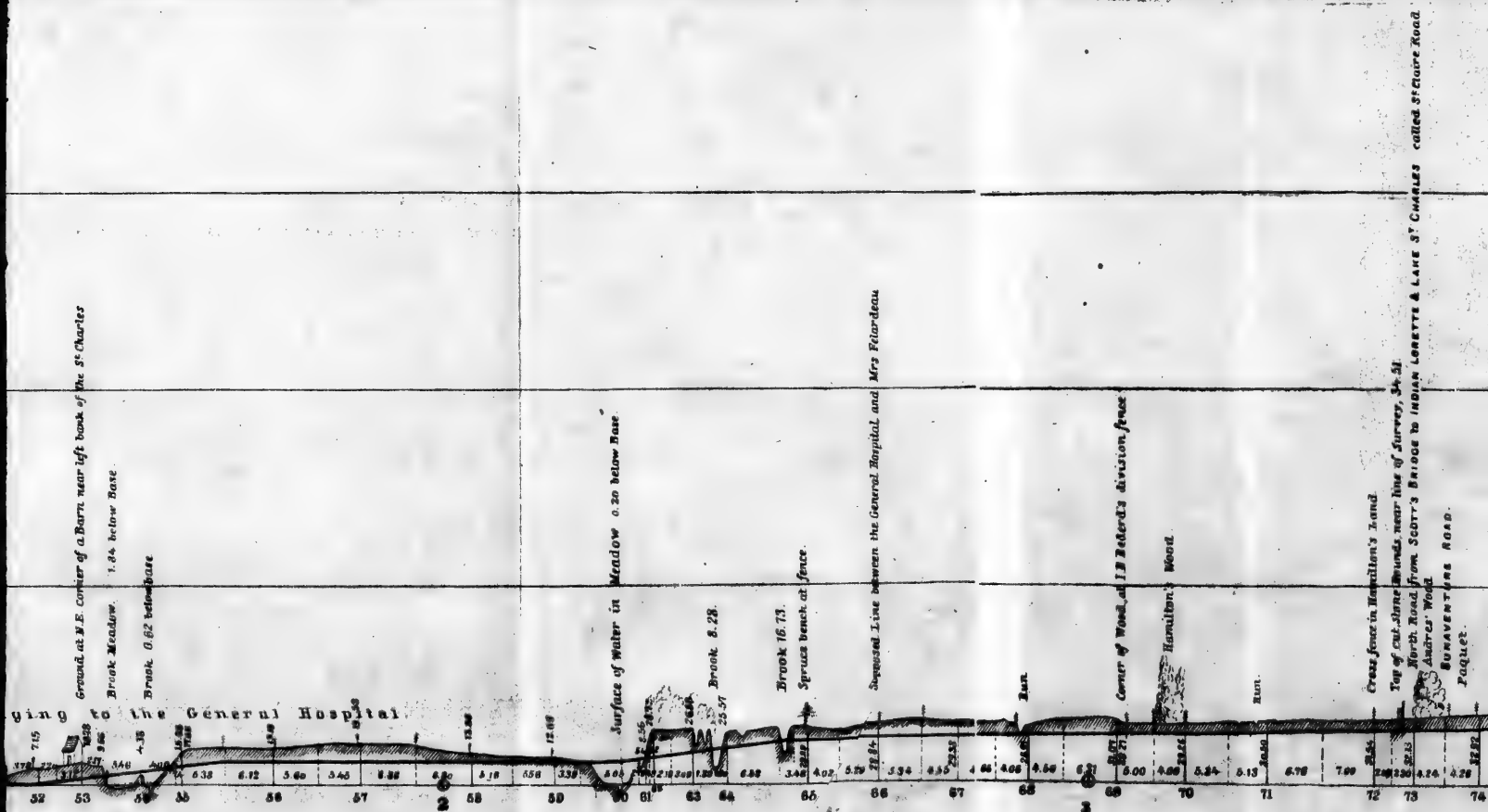
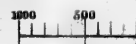
PROFILE OF THE

EXTENSION

HON. G. OKI

December,

LITH. OF E. W. BOUVÉ BOSTON.



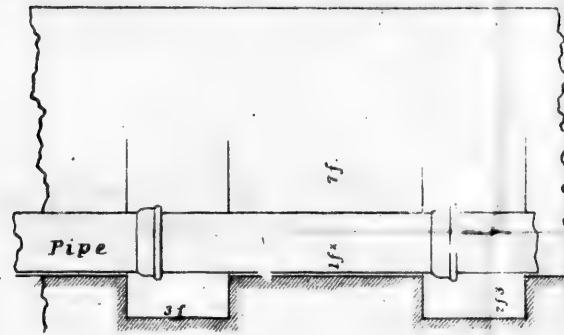
QUEBEC WATER WORKS.

PROFILE OF THE LORETTE LINE OF AQUEDUCT, -AND- EXTENSIONS IN THE CITY.

Made by Order of
HON. G. OKILL STUART, MAYOR of QUEBEC.

December, 1847. Geo. R. Baldwin Engineer.

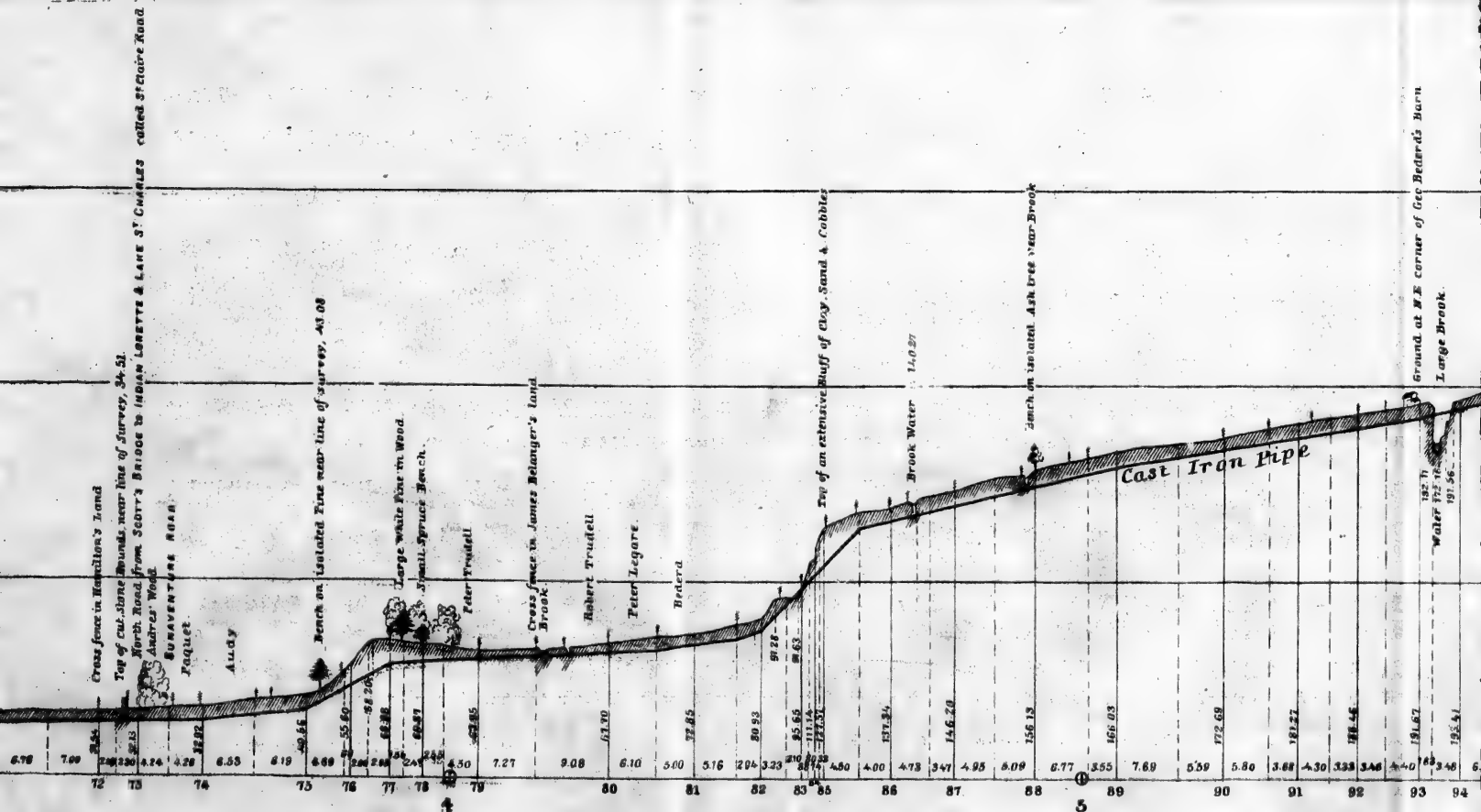
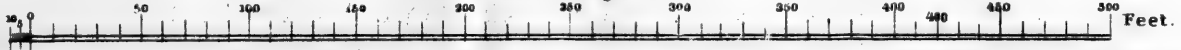
Side view of Trench.



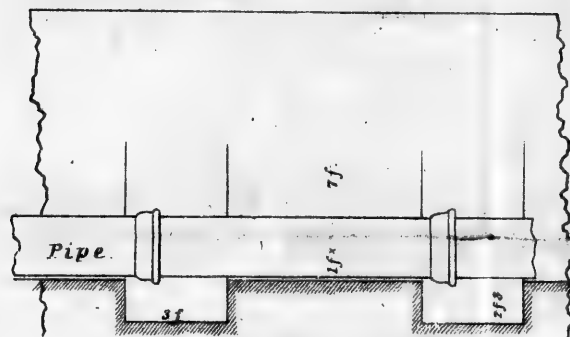
Scale for Distances.



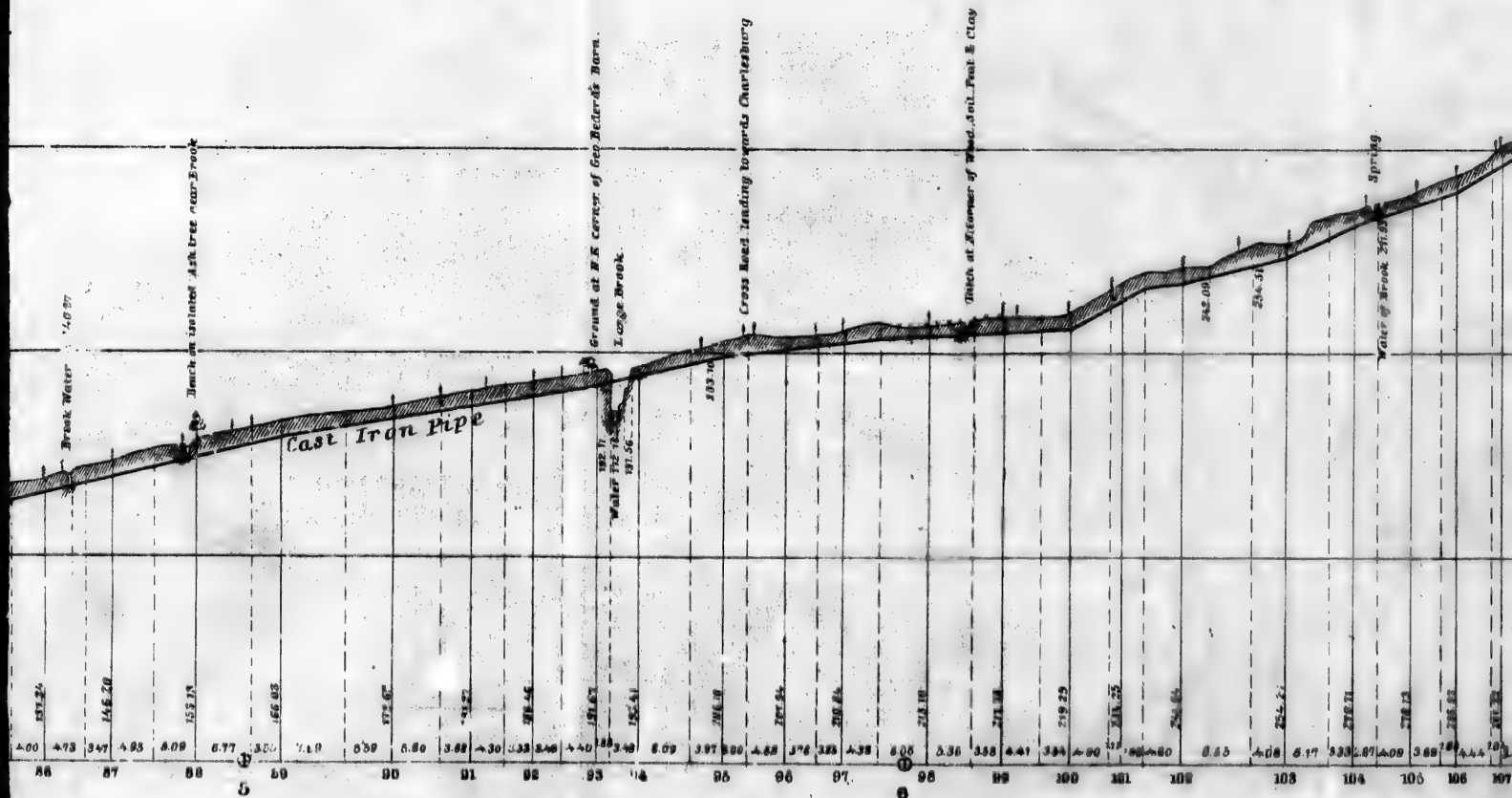
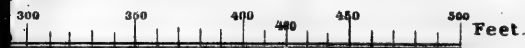
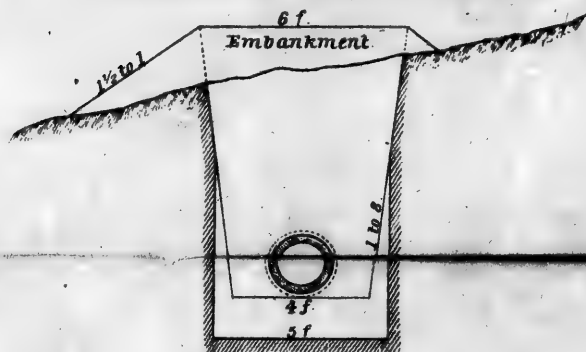
Scale for Heights.

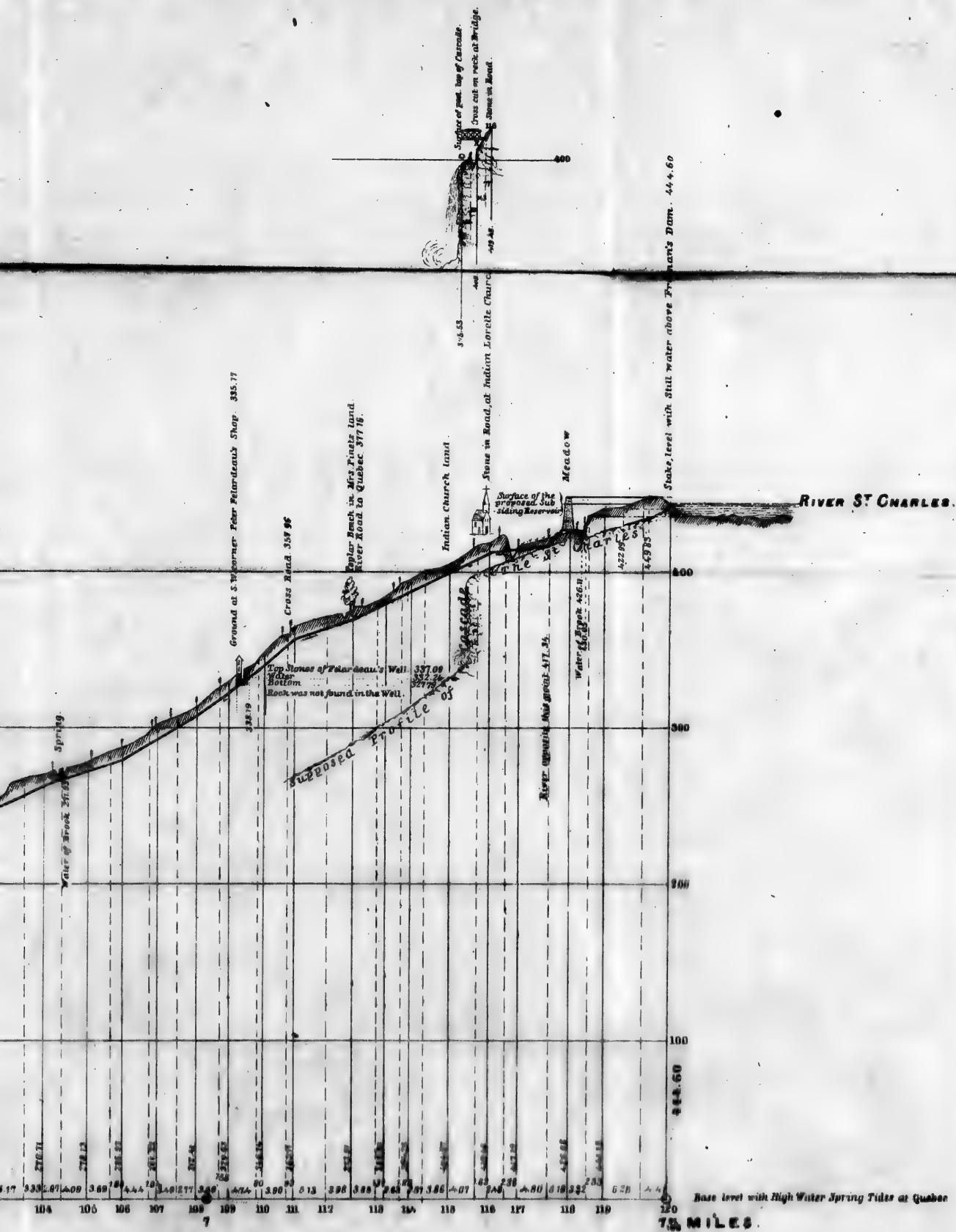


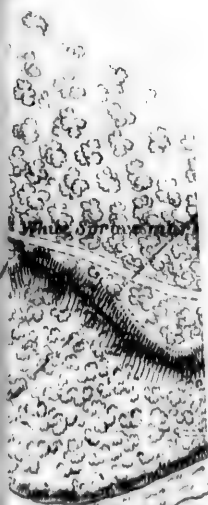
Side view of Trench.



Section of Trench with Pipe in place







RIVER







Road to Charlottetown
by the Old Dorchester Bridge

Foil house

Ruisseau la Poudre

Tannery

Clackmure

St. Douglas

Richards

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Locknire.

Richardson

Mill

Melhott's Mill Factory

Magnetic Meridian 1827

Great Salt Lake

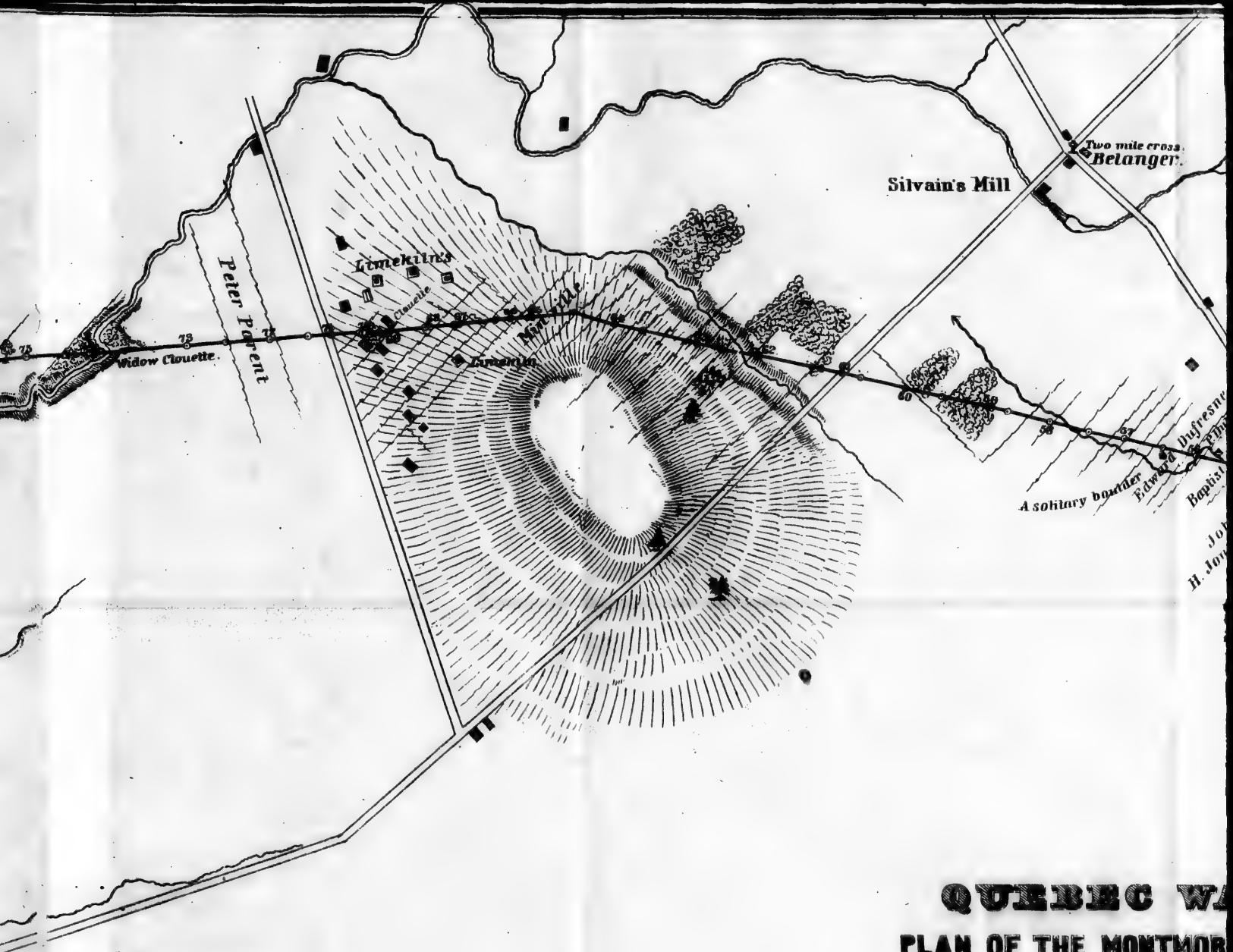
Racey's Farm House

Widow C.

BEAUPORT

BEAUPORT CHURCH

N
C
M



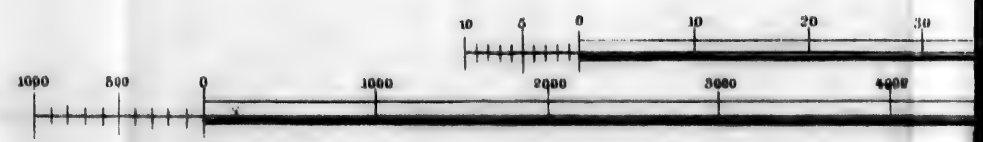
QUEBEC W **PLAN OF THE MONTMORENCY** **EXTENSIONS**

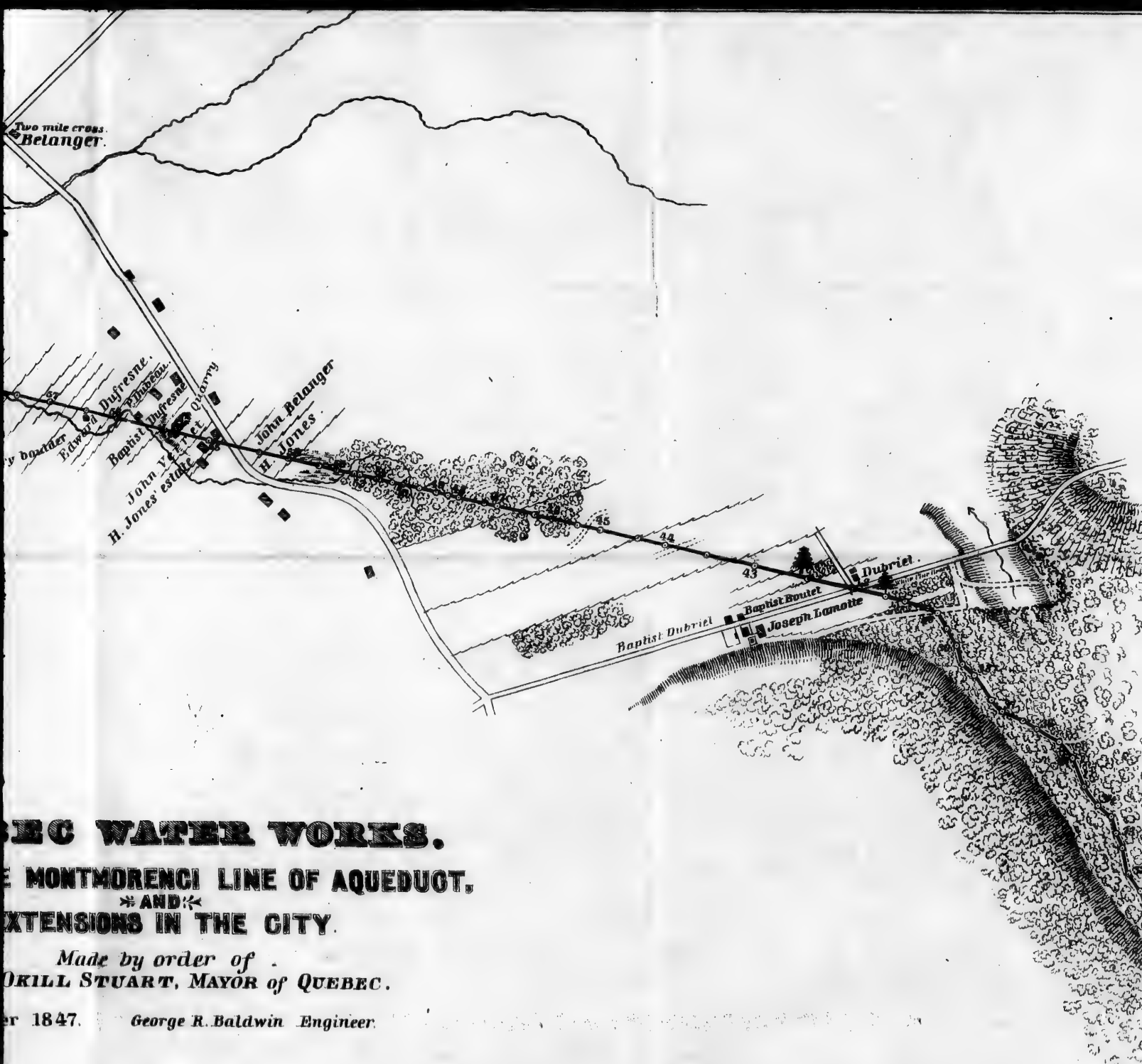
Made by
HON. G. ORILL STUART

December 1847.

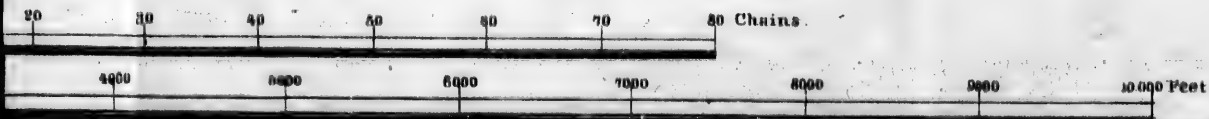
LITH. OF E. W. BOUVÉ Boston.

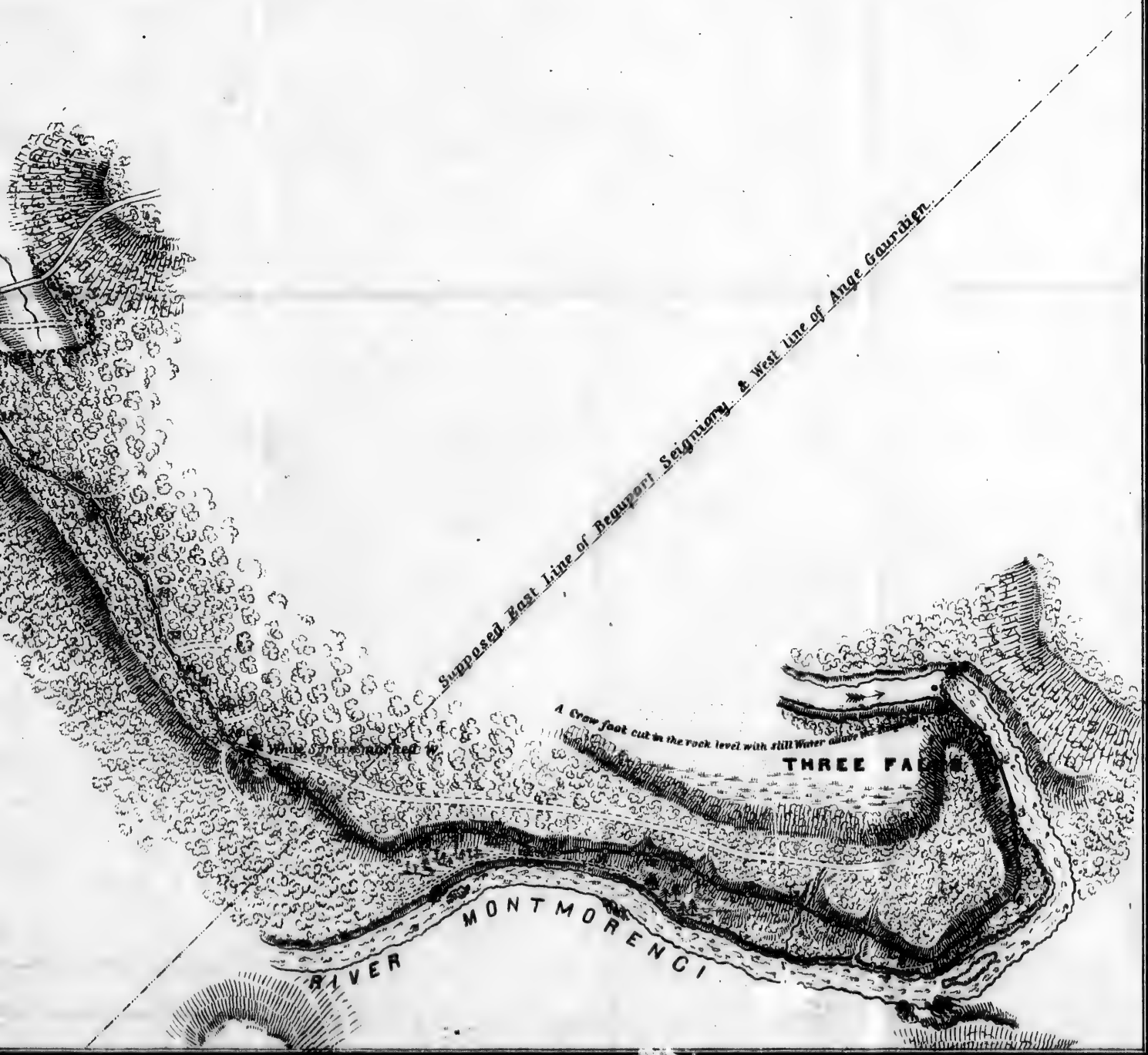
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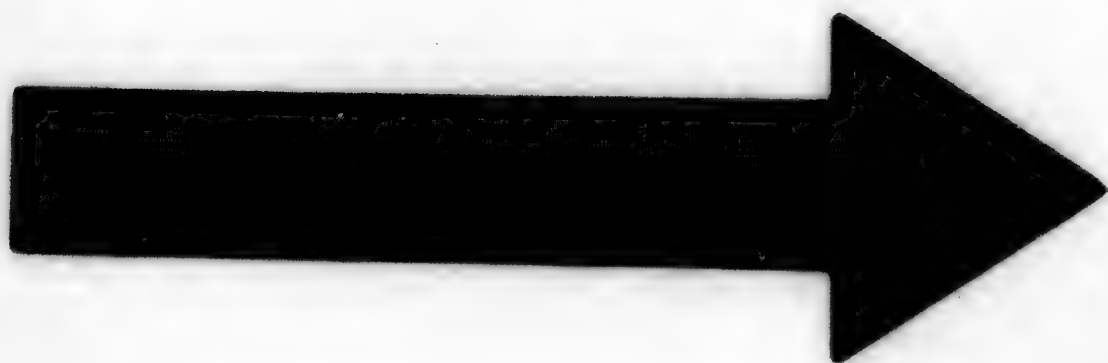




S C A L E S .







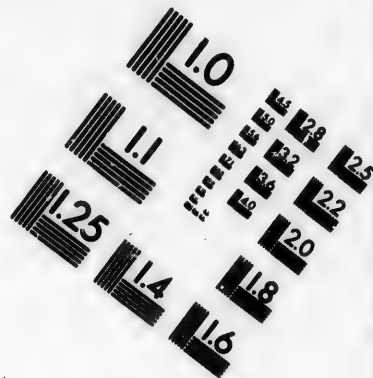
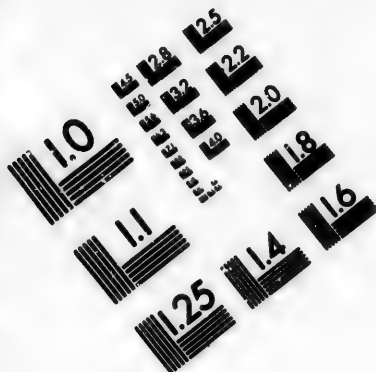
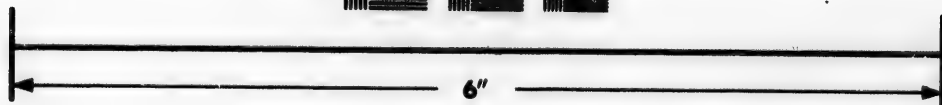
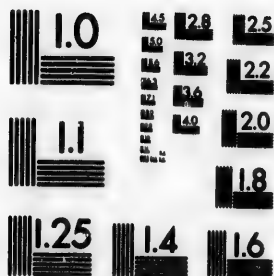


IMAGE EVALUATION TEST TARGET (MT-3)



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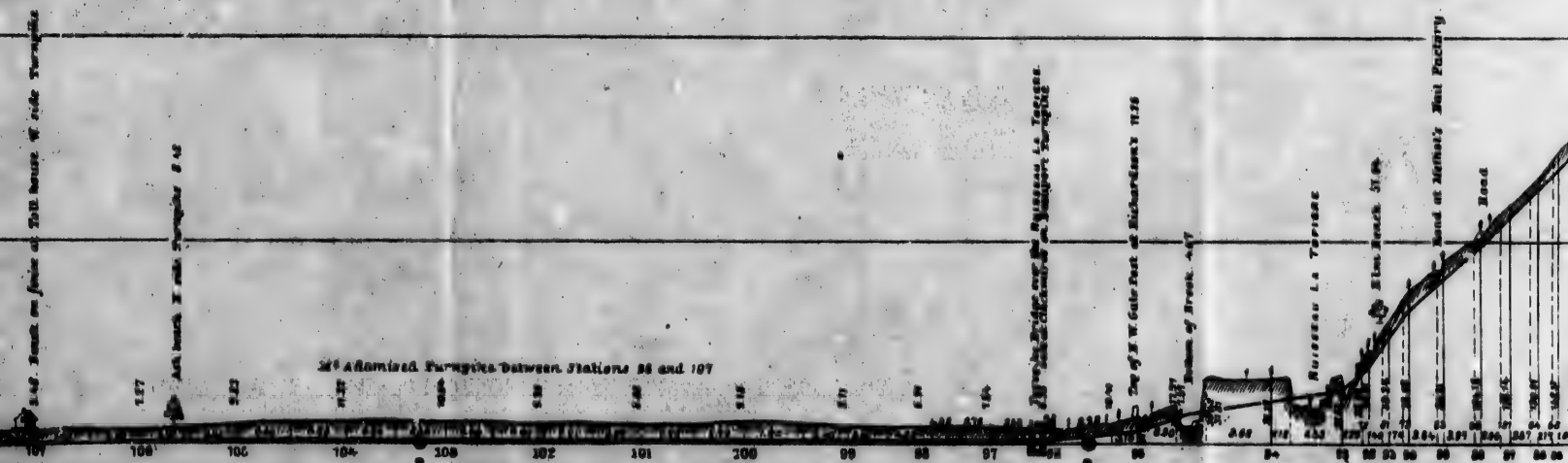
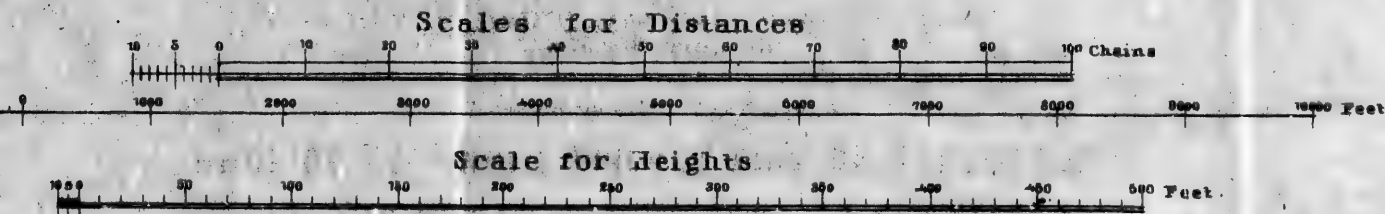
1.8 2.0 2.2 2.5
2.8 3.2 3.6 4.0

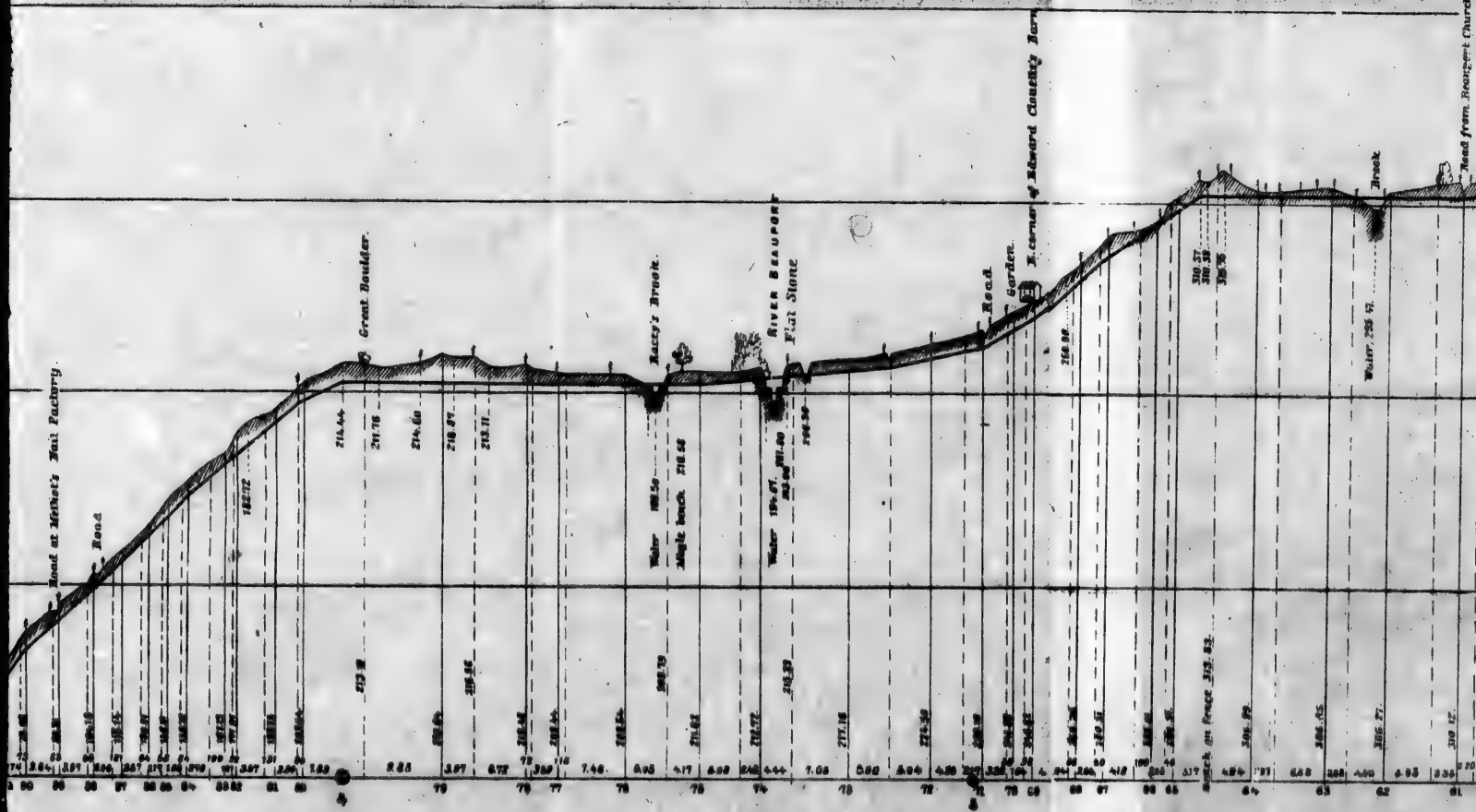
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December 1847 — George R. Baldwin Engineer.

Lith. of E. W. Howe





24

Great Boulder.

Racey's Brood.

RIVER BEAUFORT
Flat Stone

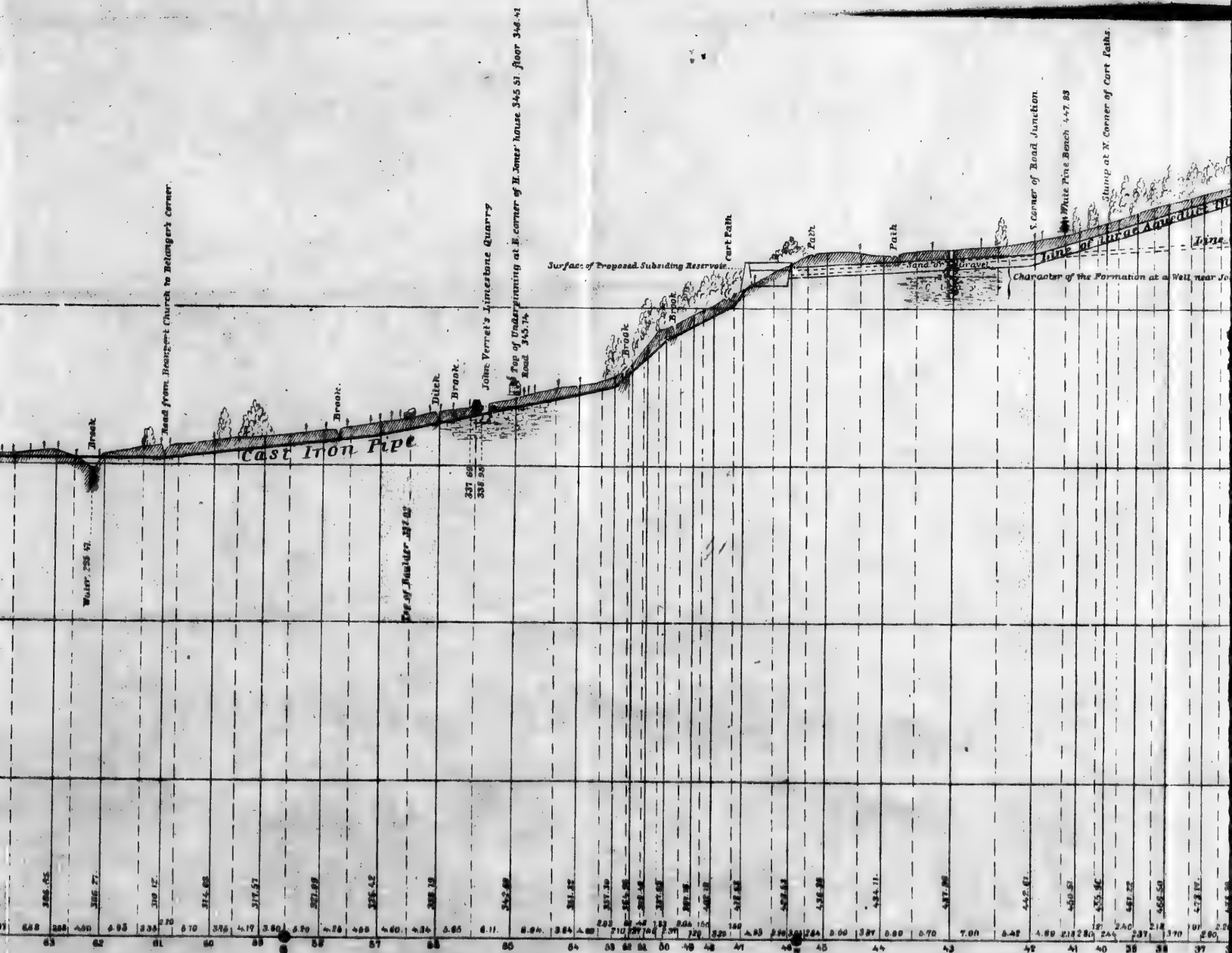
Flat Stone

lead

J. corner of Edward Clough's Barn

Water, 256 ft. Break

Read from Beazant Church to Belanger's corner.



S. Corner of Road Junction

White Pine Bench 147 83

Stump at N. Corner of Cart Path.

Spruce b. S. side Cart

Maple b. W. side Cart

White Spruce b. Marked W. Side Cart Path.

Seignior's Line

Double bench on Side Hill

Salient Angle of the Side Hill.

Bench b. on steep side hill.

Spruce

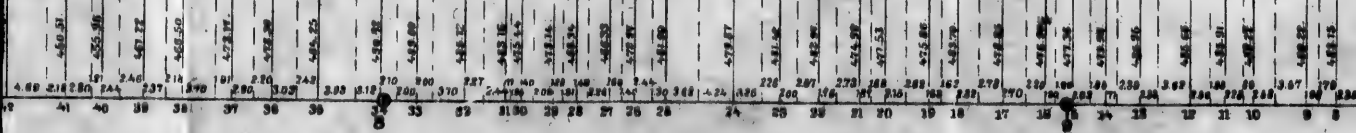
Spruce

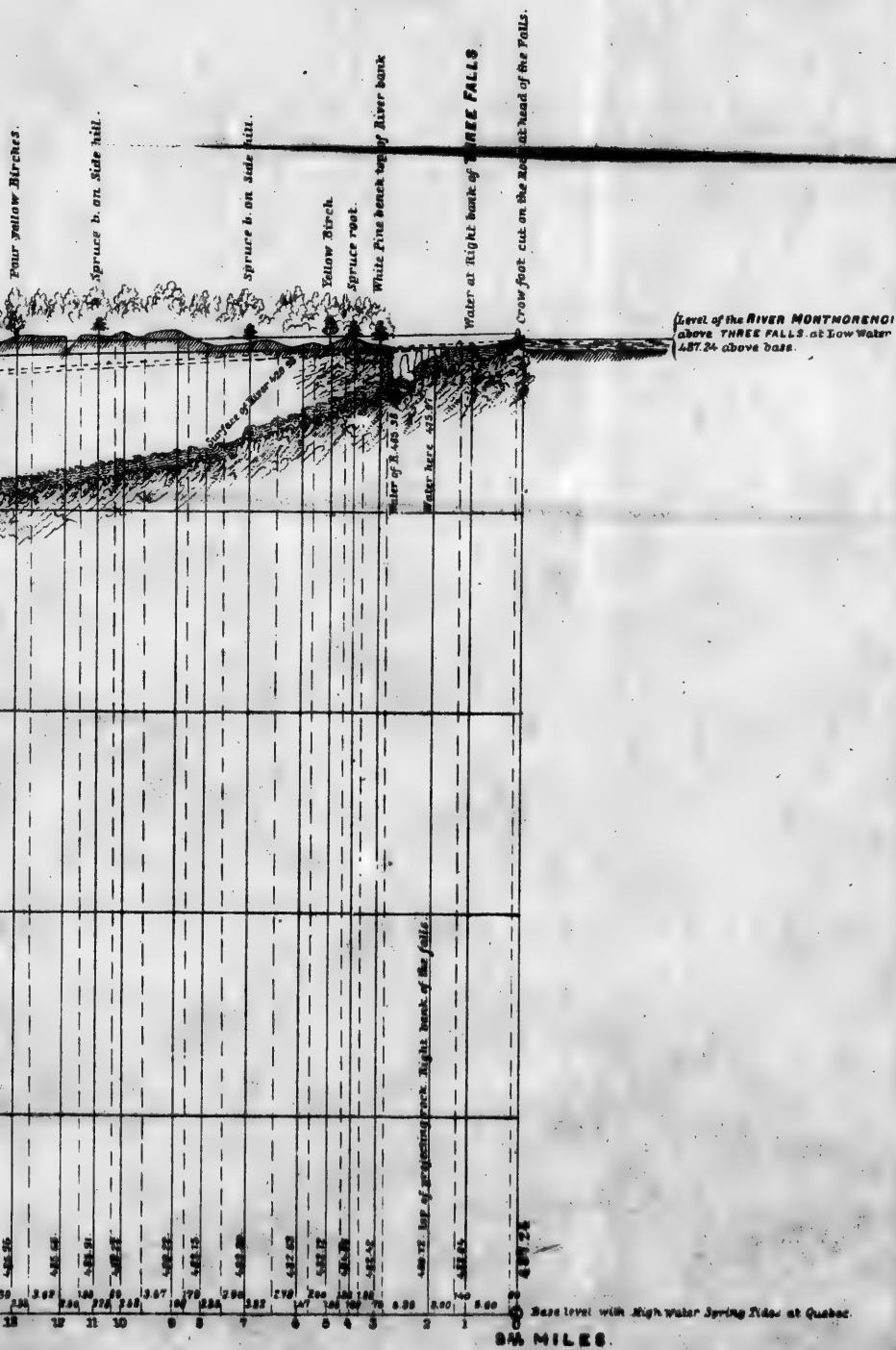
Four yellow Birches.

Spruce b. on Side Hill.

Line of Small Aqueduct in Masonry.
Line of Large Aqueduct in Masonry.
Character of the Formation at a Well near Joseph Lemaitre's house.

W. Head of the River 300 30





APPENDIX A.

ANALYSIS ON THE QUEBEC WATERS.

Report on the Chemical Examination of Samples of Natural Waters from the Montmorenci and St. Charles Rivers. By B. SILLIMAN, Jr.

TO GEORGE R. BALDWIN, Esq., Charlestown, Mass.

DEAR SIR,— Since you entrusted to my care the samples of water from the vicinity of Quebec, I have devoted to them such time and attention as I could command, directed in my inquiries into their chemical character by my former researches and the published results of others. The number of samples received from you was nine, numbered consecutively, but being taken, as I am informed, from the rivers Montmorenci and St. Charles at different points and different seasons. Four of them, (viz. Nos. 1, 3, 4, and 5,) are from the Montmorenci.

No. 1, taken at Mr. Patterson's dam, near the top of the great fall, in August, 1847. Of this sample only about one pint was supplied, which served merely as a means of comparison in the general properties of transparency, taste, smell, &c. as well also as in a very general way for the main chemical characters.

No. 3, was also taken from the same spot with No. 1, but about a month later, and was also furnished in only a very limited quantity.

No. 4, was taken from a spot one mile above Three Falls, on the 8th of September, 1847, at a time when the river was higher than when No. 3 was taken. Of this sample I was supplied with about one gallon.

No. 5. This sample of the Montmorenci water was taken up on the 24th of September, 1847, at the bridge of Mr. Patterson, above the great fall, and was supplied, to me in the quantity of about two gallons, or eight quart bottles.

Of the waters of the St. Charles River, I was supplied with four different samples, viz. Nos. 2, 6, 7, 8, and 9. No. 2 is from Lake St. Charles, near its lower extremity, and was taken in August, 1847. Only one small bottle was furnished.

No. 6, is from the St. Charles, at the dam near to Indian

Lorette, and was taken up in September, 1847. The quantity supplied was about two and a half gallons.

No. 7. This sample of the same river is from Quebec, taken up at the old bridge near the Marine Hospital, at extreme low water, on the 26th September last.

No. 8. Water of the St. Charles, just above the bridge, taken when the stream was about twelve or fourteen inches deep, and when it was rendered turbid by consequence of a fresh wind from the north east, and at low tide.

No. 9. This sample was from the "Cul de Sac," at low tide, drawn from as deep a place as it can be procured by the carts which supply the city of Quebec for present use. This sample was taken from the water-carrier's barrel. Of the last three samples, I was supplied with about a gallon each, or less.

I was informed that the two samples, 5 and 6, were those upon which it was desired that most attention should be bestowed, as it was probable that one of these two would be selected as the source of supply.

General comparison of Physical Properties. Nos. 1, 3, 4 and 5 being from the same source, were compared with each other and with a sample of pure distilled water, all being in bottles of the same size and color. No. 1 was, in this comparison, the most colorless, and yet not so transparent as No. 5, which had a somewhat darker hue of faint yellowish color, several shades beyond the colorless distilled water, and No. 3 is very similar to No. 1. No. 4 is the most highly colored and least transparent of any water in the entire series, and this is to be accounted for from the fact that it was taken up at a time of flood in the river when much extractive vegetable matter was brought in from the tributary streams. The color of this water was about that of ordinary commercial spirits of wine. The color and transparency of the Montmorenci waters are expressed by the following order of numbers, beginning with the best : Nos. 1, 3, 5, 4.

The odor and taste of all these samples were very nearly that of pure water ; only in No. 4, could be perceived a feeble odor resembling swamp water. The savor was that of ordinary soft or rain water, with a certain degree of flatness, due in great measure, no doubt, to one fact, that the samples had been some time in bottles, and had lost a portion of the air and carbonic acid which lend sprightliness to natural waters in their several sources.

All the samples were quite or very nearly free from any sedimentary matter ; a few flocculi only of brownish deposit being perceptible in No. 4.

The waters of the St. Charles, (Nos. 2, 6, 7, 8 and 9) as represented in the samples in my hands, were very similar to each other in color and transparency. The sediment in Nos. 8 and 9 is much more considerable than in either of the preceding samples; and this was to have been expected from the circumstances under which they were collected. No. 6 had much the color which was found in the Montmorenci water, No. 5, but perhaps a shade darker, and a very light brown gelatinous precipitate was seen on the bottom of the vessel. Scarcely any odor and smell could be detected in it, and after holding a quantity of it in the mouth for a considerable time, no harsh or disagreeable taste could be perceived. Both this and No. 5 are, in my opinion, almost faultless, and they certainly possess all the qualities of a good water in as high perfection as any natural waters which I have ever examined; although, in this respect, they cannot be regarded as superior to Lake Cochituate, (Long Pond) from which Boston is now about to receive her supply.

The remarks just made regarding the odor and taste of No. 6, are equally applicable to Nos. 7 and 8, although the entire amount of solid contents in these are greater than in the former sample from Indian Lorette.

No. 9 is an odorless and insipid water, similar to No. 2. It leaves a harsh sensation in the mouth after drinking, and is decidedly a hard water.

If an opinion were asked for, respecting the superiority of the waters from the higher sources of these two rivers, I should be at a loss which to choose. The water from the falls of Montmorenci is as good as can be looked for in any limestone region; very much better, of course, than any well waters of the same district of country, and perhaps No. 5 is preferable to No. 6, in color and freedom from organic matter. These characters, however, are liable to change with the seasons, and may at the present moment be reversed.

The geological character of a country will in a great measure determine the character of the streams flowing through it. It must be remembered, that water is one of the most powerful solvents known to chemists, and that it cannot fall upon the surface of the earth without becoming impregnated, to some extent, with the soluble matters of the rocks and soils over which it runs. In a country of granitic rocks, of feldspar and quartz, and the various minerals which constitute the aggregate, which geologists know by the several names of granite, gneiss, mica slate, and other rocks of the same family; the streams will dissolve out the silica and allumina, the magnesia and lime, the potash and soda, and the various acids which

are combined with these constituents, and a careful analysis of the waters of a given region may enable an acute chemist to judge with considerable certainty of the mineral nature of the country from what he finds in its waters. In a limestone region we look principally for lime and magnesia in the natural waters, and have little reason to expect the presence of many other ingredients which are found in the various minerals of a primitive country. The waters of a limestone region are generally hard, or at least not so soft as those of a granitic region. The quality of hardness is one of great importance to be known, and is owing, usually, and I believe I may say always, to the presence of soluble salts of lime and magnesia in the water. Soap forms an insoluble lime compound, lime-soap, in hard waters, which fills the water with a white curdy precipitate, harsh to the touch, and a serious impediment to the use of the water for many domestic purposes. The familiar fact that a small dose of wood-ashes, or of sal-soda, will remedy this defect in hard waters, is owing to the union of the lime with the carbonic acid from the alkali of the ash or sal-soda, and the production thereby of an insoluble, and hence innoxious compound of the lime. Perhaps no single character is of more importance to be known than that of the hardness or the reverse of a natural water.

In this particular the Quebec waters were examined by means of what is usually known as the "*soap test*," which is a saturated alcoholic solution of fine hard soap.

This test, when added in a minute quantity to soft and pure water, produces only a delicate, opaline hue, and the water containing it will immediately yield a bubble or froth on agitation. If on the contrary the water be hard, the addition of the soap-test to it at once produces a decided precipitate of a curdy white appearance, which is not dissolved by the addition of any larger quantity of water. The harder the water the more of the soap-test must be added to bring it to that point when all the lime salts are decomposed and the water becomes capable of bearing a bead or bubble. A carefully conducted experiment will enable the chemist to form an accurate estimate of the relative value, in point of softness, of a given number of waters.

* In this case the type of comparison was distilled water. Calling this 1, and an eminently hard water 10, the several waters had the following relative and comparative values in respect of hardness: Nos. 2 and 6 equal, and expressed by 2, or one degree less soft than distilled water. Nos. 1, 3, 4 and 5 equal to each other, and expressed by 3, or two degrees less soft than pure water.

Nos. 7 and 8 are nearly equal, and expressed by 4, while No. 9 is decidedly more hard than either of the series, and is expressed by 7, pure water being 1. Comparing the best, that is, No. 6, in this respect, with the water of Lake Cochituate or the Croton, the preference must be given to the two latter waters; Nos. 5 and 6 would, however, be esteemed as soft waters, and are quite sufficiently so for all useful purposes in common life.

Effects noticed on boiling these waters. The process of boiling, in waters which contain matters chemically so combined as to suffer change from this cause, often occasions a precipitation of some body previously held in solution. From this cause the culinary vessels employed to boil the waters of limestone regions, soon become coated to an inconvenient degree from the deposit of carbonate, and sometimes of sulphate of lime (gypsum), which has been previously held in solution by free carbonic acid, or which the water can no longer sustain in solution on the evaporation of a portion of its bulk. The nature of the deposit thus formed, if any, is therefore a practical question of no small interest. When water is to be used in locomotive steam engines, and other steam boilers, and for many purposes in the arts, the production of a hard and abundant crust of carbonate or sulphate of lime, deposited from the water, on the flues and other exposed parts, is a sufficient cause why purer water should be sought, or at least water free from this grave objection. It may be proper to mention in this connection that in the state of New York, the railway companies have found this deposit so great an evil in the deterioration and ultimate destruction of their engines, that they have in certain districts been put to great expense to supply themselves with purer water from remote streams or from rain.

The waters now under consideration were critically examined in reference to this interesting point of observation. A known bulk of each was moderately boiled in a suitable glass vessel, and evaporated to about one third its original bulk. In Nos. 1, 2, and 3, there was no marked change during this process. No. 4, was very much deepened in color by boiling, assuming a light coffee color, and abundant shining scales of gypsum appeared as the evaporation went on, but no ferruginous or calcareous deposit took place. It appeared afterwards that the deep color assumed by this water was entirely vegetable matter, the origin of which has already been explained.

No. 5, was slightly deepened in color by boiling, but no deposit of any kind whatsoever was formed even by the evaporation of a considerable quantity, say half a gallon to one fourth

its bulk. A taste of organic extractive matter was perceived after it had been boiled a considerable time.

No. 6 assumed a deeper color than 5, and gave off an abundance of air-bubbles before the boiling commenced; there appeared a slight precipitate of brownish organic matter, but no scales of gypsum, or other solid mineral matter. It should be remarked, however, that on the evaporation approaching entire dryness, that the solid contents of these waters, such as it is, are no longer capable of being sustained in solution, and make their appearance as a sediment.

Nos. 7 and 8 were much deepened in color by boiling, and deposited abundant scales of sulphate of lime and brown ferruginous looking matter. The coloration of 8 was not so intense as of 7, but it became quite turbid with the scales of gypsum thrown down in it; the escape of copious bubbles of dissolved air was very noticeable in this water.

No. 9 was not much changed by boiling, but it was rendered much more turbid than either of the others with broad and abundant scales of gypsum.

The *nature* and quantity of the solid contents of a water left on evaporation, of a known quantity, is then a question of the greatest practical interest, as well as whether such deposit takes place wholly or in part before the water has been reduced to entire dryness. It is evident from the foregoing statement, that the constant use of several of these samples, especially of Nos. 7, 8 and 9, in steam boilers and other similar situations, could not fail to produce a deposit of solid ingredients thrown down by the mere boiling of the waters, and peculiar management and care would be required to avoid the risk of injury thus incurred. Nos. 5 and 6 are in this respect much less open to objection. In connection with the amount of solid contents in a given sample of water, it might very naturally be inferred that the specific gravity or comparative weights of a given bulk of each water, would be a safe guide, those having the most foreign matter, also having the highest specific gravity. The density of these waters has been most carefully compared with that of distilled water in an apparatus of the best construction. The results are given below, and it will be seen, that even in No. 9, which is the least pure of all, that the amount of solid contents appears only in the fifth decimal place.

I should by no means trust such results as these, if they had been procured with an ordinary balance, and with only that degree of care usually directed in such cases. The balance used was one of Oertling's best, manufactured in Berlin, and sensible with great precision to the $\frac{1}{10}$ milligramme; the tem-

perature in each case was carefully regulated, and the contents of the bottle accurately regulated by a closely fitting plate of mica, which covered the capillary orifice of the perforated stopple, and entirely prevented the evaporation of any sensible portion during the operation of weighing. These precautions may appear to be uncalled for, but without them no precise results can be obtained or confirmed. The results are here exhibited.

Table, showing the specific gravity of the waters at 15° C.

Number of waters.	1.	2.	3.	4.	5.
Specific gravity.	1.0000329	1.000016	1.000016	1.0000659	1.0000164

Number of waters.	6.	7.	8.	9.	
Specific gravity.	1.0000329	1.000064	1.0000329	1.000082	

It would not be inferred from this table that there was much reason to look for an appreciable quantity of solid ingredients in a gallon or other limited quantity of these waters; and in truth, the quantity is far less than is usual, as will appear on a comparison of their solid contents with that of other natural waters.

The weights and measures employed in these examinations were the French decimal system. The weights are the gramme, which is equal to the cubic centimetre of distilled water at the standard temperature of maximum density. It is equal to 15.433 grains troy. The unit of liquid measures is the *litre*, which is a cubic decimetre, and contains 1000 grammes (one thousand grammes) of distilled water. The litre is equal to 61.074 cubic inches in United States measure, and to 1.057 quart, wine measure. The advantage of employing these weights and measures in examinations of this description is, that there subsists a relation between the units of weight and measure which is highly convenient, and which is not found in the standards of England and America. It is also perfectly easy to convert the one into the other. The United States standard gallon contains 231. cubic inches of distilled water; it is, therefore, less than 4 litres by the amount of the following

Expression. 4 litres = 244.296 cubic inches,
 1 gallon 231.

13.296

The United States standard gallon holds at 15°C. 58,364.6509 grains, and at the temperature of 3° C., or 39.83° F. (the temperature at which this standard was adjusted,) it holds 58,372.1754 American standard troy grains.

In determining the weight of solid residue in the Quebec waters, a carefully measured quantity of each was gently evaporated to a small bulk in glass vessels, and the residue then transferred without loss to a large platinum basin of known weight. In this the evaporation was carried in a water bath to entire dryness, and the weight of the residue determined; this weight was repeated several times, trying the capsule each time at a temperature of about 300° F. until a constant result was obtained.

The vegetable matter, which was found in each case to a greater or less degree, was then burnt off by heating the capsule to redness over an alcohol lamp. During this ignition, the occurrence of a rapid combustion running over the inner surface of the basin, and destroying the organic matter before the capsule was fully red, was attributed to the presence of some salt of nitric acid; e. g. nitrate of soda or potash. The portion which remained after the ignition, was regarded as the non-volatile inorganic or mineral matters present in the water, while the loss of weight experienced during the operation was mostly owing to the organic matter, derived from vegetable and other sources. This determination was made only in case of Nos. 4, 5, 6, 8 and 9. Of the other samples there was not enough at command to go through with other testings and this also, and it was supposed that these five samples would yield all the results which could be expected from the others.

No. 4. One thousand grammes of this water were very carefully evaporated as above described, and the weights of the residue determined with the greatest nicety possible. To avoid all needless complexity in the statement of the results, I purposely omit all the details of steps gone through to obtain the final weights.

The total residue of 1000 grms. of No. 4=000.042; or 100,000 lbs. (or parts) of such water will contain 4.20 parts (or lbs.) of solid matter.

Of this quantity there is volatile at redness 2.58 parts

Leaving for non-volatile mineral matter 1.62 "

A gallon of this water contained in round numbers 2.5 (two and a half) grains of which, nearly $\frac{2}{3}$, are vegetable organic matter.

The residue of this water, after evaporation, was of a deep coffee brown color, and shrunk much on drying. It burnt with a strong organic odor, and left a minute white deposit, which had a slight alkaline reaction, and did not effervesce with hydro-chloric acid. The chemical examination of this water discovered in it the presence of lime, magnesia, sulphuric acid, chlorine, and carbonic acid, with feeble traces of alumina, iron and soda. Of course the quantities of these several constituents are very small indeed, and they could be detected only after considerable concentration. The water, in its *natural* condition is neutral, and gives, with the appropriate tests, no evidence of either chlorine, iron or magnesia, with only a very feeble trace of sulphuric acid. Only the lime and magnesia were determined quantitatively, and these estimated as sulphates very nearly accounted for the small dose of mineral matter which this water contains.

The amount of carbonic acid was determined in this and several others of the waters by passing the vapors from a known volume of the water into a solution of baryta in water, the carbonate of baryta found in the process was converted into sulphate of the same earth, and weighed, and from its weight the corresponding volume of carbonic acid is easily calculated. The quantity of carbonic acid contained in 1 litre of this water, or 1000 grammes is 00968 gramme by weight = .298 cubic inch, or about *one* cubic inch per gallon of the water. My former experience leads me to believe that in its natural source it contains much more than this quantity, and that a portion has been lost, by the water standing for some months in a glass bottle before it was examined. The organic matter of this water did not yield any reaction which would identify it with either crenic or apocrenic acid, the two vegetable acids most commonly found in fountains or lakes. Too little of the water was at my command to determine with certainty the presence of silica, phosphoric acid, and several other ingredients which are occasionally detected in natural waters. It is to be remembered that 100 tons of this water would contain only 3.24 pounds of mineral matter.

No. 5. The determination of the solid residue of this water was made on a quantity of 4000 grammes. The residue was of a light brown color and trifling in quantity. Its weight,

taken with the precautions already described for No. 4, was from 4000 grammes	0.1455 gram.
Equal in 100,000 parts to	3.63 parts.
This, at redness, lost volatile organic matter	0.0525 gram.
Leaving of inorganic or mineral matter	0.0930
Original weight, or 4 litres	0.1455

In 100,000 parts, therefore, we have

Organic matter	2.32
Inorganic or mineral	1.31 parts.
100 tons of such water contains, of	
Organic matter	4.64 pounds.
Mineral matter	2.62 "

This residue on ignition, burnt with some vivacity, as if from the presence of nitric acid, and the odor of burning organic matter was very perceptible during the first part of the ignition. The non-volatile portion of this water was of an earthy appearance, possessed an alkaline reaction, and did not effervesce very much when treated with hydrochloric acid.

Analysis detected in this water, a trace of *iron*, rather a larger amount of *alumina*, a trace of *lime*, soda and magnesia. No reaction was manifest by the usual test for chlorine (nitrate of silver,) nor did this delicate reagent betray the presence of any organic acid,—by the changes of color which accompany and follow the application of this test in those waters containing such acids, and which, in many cases, are exceedingly beautiful and characteristic. The carbonic acid gas in a gallon of this sample did not exceed (determined as already described) 1.2 cubic inches. In this case, also, the lime and magnesia alone were determined. The sulphuric acid (whose presence was proved as well as that of chlorine) was not in sufficient quantity to be determined. Could a larger quantity of this water be evaporated, e. g. several hundred pounds at least, the relative proportions of its constituents could no doubt be made out. But of what practical value could such a result be on a water which is so pure as to contain only about 0.55 grain to the gallon of *mineral matter*? Such water is almost pure enough for any chemical purpose whatever.

No. 6. More of this water was furnished to me than of either of the others, and I hoped to be able to determine the proportions of each of its several constituents. But the possession of ten times as much could hardly have afforded me

the means of making a quantitative analysis of it upon which I should have been willing to rely.

Analysis showed it to be less pure than No. 5, and it yielded to tests, evidence of containing a very feeble quantity of sulphuric acid, chlorine and lime, with more of alumina tinged by a trace of iron — magnesia and soda were also present, and an abundance of organic matter.

4000 grammes of No. 6 yielded, on evaporation,		
Solid contents		0.231 gram.
Or in 100,000 parts		5.77 parts.

Ignition expelled from this.	Organic	0.0906 gram.
Leaving solid inorganic matter		0.1406 "

In 100,000 parts, therefore, we have,

Of volatile, solid contents,		2.26 parts.
Of non-volatile, contents		3.50 "

The residue of this water, before ignition, was dark colored brown and glairy. It burnt with a vivid sparkling, as of nitrates, and left an ash which was strongly alkaline, and not entirely free from carbonaceous particles. The action of dilute hydrochloric acid occasioned a feeble effervescence from the escape of carbonic acid. It contained .007 of lime, and .0089 gramme of magnesia to the 1000 grammes. The carbonic acid in this water was equal to nearly 1.5 cubic inches per gallon.

No. 7. I had not sufficient of this water to enable me to determine its total of solid contents. Tests, however, made known the presence of carbonic acid, chlorine, sulphuric acid, lime, magnesia, and alumina. The magnesia was equal to .0047 gram. in 1000 grammes of the water, and the lime to .0056 gram. in the same quantity, and of chlorine .0025 milligramme. The free carbonic acid was not determined from want of sufficient quantity of the water.

No. 8. The solid contents of this water amounted on		
1000 grammes to		0.081 gram.
Or in 100,000 parts		8.10 parts.
Ignition expelled from this,		2.72 "
Leaving solid mineral residue		5.38 "

The residue, after ignition, was very strongly alkaline in its reaction, but effervesced very feebly with hydro-chloric acid. Only a qualitative analysis was made of the contents of this water, which indicated as in the others, chlorine, sulphuric acid, carbonic acid, lime, magnesia, alumina, and oxid of iron, with traces of potash and soda. The quantity of carbonic acid

was a little over 1.5 cubic inch per gallon. The quantity at my command was too small to make a quantitative analysis.

No. 9. The residue of evaporation of 1000 grammes of this water gave 0.1192 gram.
Or in 100,000 parts 11.92 parts.

The residue of this water had a light salmon color, and an earthy appearance, with only a narrow areola of brownish organic matter. On ignition it charred slightly, burnt white, and on being moistened it manifested with test papers a strongly alkaline reaction, and effervesced slightly with hydro-chloric acid.

Ignition expelled from this residue of 1000 grammes 0.438 gram.
Leaving inorganic matter 0.754 "

The amount of carbonic acid in a gallon of this water is slightly more than 3 cubic inches per gallon.

The inorganic matter gave evidence of the same constituents which have already been enumerated under the foregoing samples. Magnesia and lime combined with sulphuric acid and chlorine are the predominating ingredients. When we consider the comparatively small amount of solid contents even in this water, which is so much more impure than either of the foregoing, we are constrained to admit that Quebec is peculiarly fortunate in having the choice of waters, the most impure of which is more free from foreign matter than the Schuylkill, the source of the waters supplied from the celebrated Fairmount water works in Philadelphia. It may reasonably be doubted whether the very small quantity of salts of magnesia and lime, which the waters of the St. Charles at Quebec contain, can justly be regarded as the cause of the disturbance which travellers experience on visiting Canada. Is it not more probable that the water from wells, and the change of climate, are more efficient and probable causes?

For the convenience of a general comparison of the several determinations, which have been enumerated with other waters of known celebrity, the following table has been made. The analyses of Croton, Cochituate and Schuylkill water, were made by the writer in 1845, for the city of Boston. One fact of some interest appears from the analysis of the Lake Cochituate water, namely, that the water taken up from near the bottom of the lake contains much more impurity than that upon the surface. A similar observation has been made regarding the water of the ocean; but I am not aware that attention was ever called to this inequality in the higher and lower levels of bodies of fresh water, until the publication of the report by the author, from which these results are quoted.

Table, showing the quantity of foreign matters in Quebec waters, as compared with other sources in the United States.

Number of the water.	4.	5.	6.	8.	9.
Solid matter in 100,000 } parts by weight.	4.20	3.63	5.77	8.10	11.92
Volatile at redness.	2.58	2.32	2.26	2.72	4.38
Leaving solid.	1.62	1.31	3.50	5.38	7.54
Number of water.	A.	B.	C.	D.	E.
Solid matter in 100,000 } parts by weight.	18.714	3.168	5.770	9.417	87.85
<i>In one gallon.</i> Volatile at redness. }	4.28	1.85	1.16	1.24	1.218
Leaving solid in 1 gallon.	6.66	0.63	2.21	4.26	50.055
Grains in 1 gallon.	10.93	1.85	3.37	5.50	51.274

Nos. 4, 5, 6, 8, and 9, are the waters of this report.

A, is the Croton, in New York; B, Lake Cochituate, (or Long Pond,) from the surface; C, the same, from a depth of sixty-two feet; D, the Schuylkill, at Fairmount, Philadelphia; E, a well on Beacon Hill, in Boston, showing the general character of most of the wells in that city.

A conclusion which may safely be drawn from the chemical examination of these waters, is, that they contain nothing in any way injurious to the human system, and that they are so pure, especially Nos. 5 and 6, as to be fit for the most delicate purposes of the arts of life. There is a vulgar notion, that river water, and lake water — or pond water, as it is called — are not so well adapted for domestic use as the water of wells; this prejudice cannot stand long in a community, which is so happy as to have a full supply of water as pure as the Croton, Lake Cochituate, or it may be added, as the Montmorenci, or St. Charles, at Indian Lorette. It has been made an objection to the use of lake and river waters, that they contain numerous animalcules — of strange forms and singular voracity! as if such animals were not also found in the waters of wells and fountains. The fact, that a natural water was entirely free from these creatures of purification, would be, to my mind, proof that there must be something wrong about it which had unfitted it for the support of these delicate organisms, and might, therefore, render it unfit for human use. The waters of Quebec have passed under the all-seeing microscope of our distinguished countryman, Prof. J. W. Bailey, of West Point Military Academy, and his letter is here appended.

" WEST POINT, (N. Y.) Oct. 14, 1847.

" My Dear Sir,

" By the request of Mr. G. R. Baldwin, of Charlestown, Mass. I send you the results of my microscopic examination of some specimens of water from the neighborhood of Quebec, the chemical analysis of which is, I believe, to be performed by you. I myself, attach but little importance to the results given by the microscope, with reference to the quality of the water and its fitness for use. The purest natural waters are never entirely free from animalcules, but it is only when these waters have been kept standing for some time in contact with organic matters that they develop in sufficient quantity to affect the quality of the water. As Mr. Baldwin appeared anxious to have the waters examined by the microscope, I could not decline, and I now send you, as he requested, a statement of the results.

The specimens were nine in number, in phials holding about three cubic inches of water. Having satisfied myself, by careful examination, that the water above the sediment in each bottle contained no organic bodies, I then poured off nearly all the water, leaving a small portion in each phial, with which I then rinsed out the sediments separately, and poured each into a watch glass; these sediments were then examined by the microscope with a power of about 350 diameters, and the contents of each are given below.

No. 1. Sediment almost none. No organic bodies detected.

No. 2. Sediment small, containing a few colorless angular mineral fragments, with a few siliceous infusoria, among which were *Gomphonema acuminatum*, Ehr. (see Amer. Bacillaria in Silliman's Jour. Vol. XLIII. pl. V. fig. 6); *Tabellaria trinobis* (L. C. Vol. XLII. pl. II. fig. 36.); *Fragillaria pectinalis*, L. C. fig. 41; *Gaillonella aurichalcea* L. C. fig. 4; *Gaillonella distans* L. C. fig. 5; Spiculæ of *Spongilla* were also found, and one small *Peridinium cinctum*, Ehr.

No. 3. Sediment small; nothing organic detected.

No. 4. Sediment very small; one small hair, a bit of *Sphagnum*, and a few young *Naviculæ* were all the organic bodies found.

No. 5. Sediment very little, containing no organic bodies except a fragment of a *Cyclops*, and a small plate of *Fragillaria pectinalis*.

No. 6. Sediment small, containing a fragment of *Cyclops*, one small *Acarus*, some very minute *Naviculæ*, and *Tabellaria trinobis*, Ehr.

No. 7. Sediment small, containing one living and active *Euglena viridis*, also *Fragillaria pectinalis*; *Gaillonella auri-*

chacea; some minute Naviculæ, stephanodiscus Niagaræ, Ehr.,* &c.

No. 8. Sediment much more abundant than in preceding specimens, containing many angular particles, apparently of Quartz and Hornblend, with many specimens of Surirella splendida Ehr. (Am. Bac. L. C. pl. II. fig. 21,) Stephanodiscus Niagaræ; Synedra ulna (Am. Bac. L. C. pl. V. fig. 2.) Navicula suecica (Am. Bac. L. C. pl. II. fig. 20,) with spiculæ of Spongilla.

9. Sediment small, with a few minute Naviculæ, and Arthrodesmus quadricaudatus (Am. Bac. L. C. Vol. XLI. pl. III. fig. 17.)

The sediment of all the specimens contained a portion of matter resembling coagulated albuminous matter, entangled among which were the angular bits of minerals and the shells of the animalcules.

It may be a comfort to some persons to know that the siliceous organisms above referred to as animals, are by some writers considered as plants.

Very sincerely your friend,

J. W. BAILEY."

On the use of Metallic Lead and Cast Iron, to convey and distribute the Waters of Quebec.

The most important consideration in reference to the supply of water to a great city, next to its original purity and abundance, is to guard against its being contaminated by the means employed in its distribution to the consumers. The calcareous matters dissolved out of the masonry conduit, through which the Croton river runs for forty miles before reaching New York, were found to alter materially the purity of that water, and render the total amount of its solid contents considerably greater after the water reached the city than they were in the river, or great reservoir at the commencement of the aqueduct. This, however, proved to be a very limited evil, and soon corrected itself. Not so, however, the effect of the water on the leaden pipes, employed for its distribution from the iron mains to the houses of the consumers. The writer, in 1845, made a carefully conducted set of experiments on several waters now used in our larger cities, and among others on the Croton in reference to its effect on leaden pipes. The general result was, that the Croton water only very slightly

* This is a beautiful genus allied to Gaillonella, specimens of which I first found at Niagara Falls, and sent to Ehrenburg, who has described it in the Reports of the Berlin Academy for February, 1845, p. 28.

attacked lead. But it was impossible, in a single set of experiments, to meet all the conditions found in the actual distribution of water to a large town; and one of these conditions which was not taken account of, was the effect of the iron pipes in altering the electrical or chemical relations of the lead. It has since been found in practice, that this condition is a very important one, and must always be regarded.

Pure water has a very remarkable power in dissolving the oxyd or rust of lead; so much so, that a pint of pure distilled water will dissolve a grain or more of this oxyd. The common air and carbonic acid, always found in natural waters, materially aid in the solution of the lead, by first oxidizing the clean surface and thus placing it in a condition to be acted on; while on the other hand, it has been confidently asserted that the presence of various impurities in water, such as sulphate of soda or sulphate of lime, and other saline ingredients, would wholly or partly arrest the corrosion of lead. It is certain, that natural waters vary very much in their power of acting on lead, and very many are so nearly exempt in this particular that they have been drawn for years with impunity through leaden pipes. This may be owing to the non-action of the water, or to its producing an insoluble and innoxious compound with lead. Thus water, highly charged with organic extractive matter, has, in some cases of my own observation, been brought into contact with lead without being at all contaminated therewith, while abundant evidence of action was found in the precipitation from the water of all its organic matter in an insoluble state, and by the gain of weight in the lead itself. The lead may, even by this process become, as it were, varnished over with a film of organic matter, and the water escape unharmed. The chlorid and nitrate of lead, salts, the former of which may often be found in waters that have passed through leaden pipes, are both represented as being quite harmless when taken into the system. It is the sub-oxyd and carbonate which are the most deadly forms of lead; for although the carbonate is a white powder, insoluble in water, it is easily dissolved in the acids of the stomach, and is the form in which most cases of lead poisoning occur.

To try the effect of the Quebec waters on lead an experiment was instituted, in which a thin and bright strip of lead about one foot long was exposed in a close glass bottle, with a sample of each water for a long time. The lead was perfectly bright when the water was added to it, and frequent observations were made for such changes as might appear. The weight also of each slip was carefully noted before the experiments, that any change which should happen might be dis-

covered, either of increase or of diminution. Another series, in a distinct set of bottles, was also prepared, similar to the first, in all respects except in the attachment of a small slip of brass to one end of each leaden strip. This was for the purpose of imitating more closely the condition of a leaden aqueduct pipe, with a brass stop-cock on its end. This arrangement, of course, alters the electrical relation of the lead, and places it in a situation to be more easily acted on by corroding agents. Common air, except such quantity as was dissolved in the water, was excluded, as it is in the general use in aqueducts. In this particular, the leaden pipes of wells and cisterns differ in their situation from those of aqueducts. Since in the former there is a line where the water, the metal, and the air join, and at that point is the greatest activity of chemical action. At the conclusion of the experiments it was found that each of the waters had become more or less impregnated with lead. Within twelve hours after the first experiment was instituted, it was evident, from simple inspection, that some action had taken place in Nos. 7, 8, and 9. Each of these slips had become tarnished, and particularly No. 9, while the others remained bright and untarnished. This effect did not appear to increase at all after the first twenty-four hours, during many days and even weeks in which the experiment was continued.

The second series, in which a slip of brass was soldered to each, became acted on after two or three hours, especially in Nos. 4, 7, 8, and 9, while in Nos. 5 and 6 the lead remained quite bright to the end of the experiment. The results of these trials are given in the following tables.

Table, showing the effects of Water on Lead.

No. of the water.	1.	2.	3.	4.	5.
Weight of slip before exp't.	7.0150	7.34825	7.5430	7.5318	7.490
Weight after exposure.	7.0011	7.34760	7.5419	7.5315	7.492
Difference + or -	+ .0139	— .00065	— .0011	— .0003	+ .002

No. of the water.	6.	7.	8.	9.
Weight of slip before exp't.	7.355	7.5042	6.9265	7.4960
Weight after exposure.	7.355	7.5061	6.6290	7.4985
Difference + or -		+ .0019	+ .0025	+ .0025

When samples of all the water which had been in contact with the lead were tested with sulphureted hydrogen water, immediate coloration from sulphuret of lead was seen in each,

but in very different degrees. Those which, to appearance, had acted most upon the lead were found to be almost free from taint, (viz. Nos. 8. and 9,) showing that while the lead was tarnished, the compound which was formed was an insoluble one, and this was also indicated by the increase of weight in these slips. The degree in which the contamination from lead was observed is expressed in the following order of numbers, beginning with that which gave the least evidence of lead, viz. Nos. 8, 9, 7, 3, 5, 2, 6, 1, 4. Nos. 1 and 4 assumed a clove brown color from the larger quantity of sulphuret of lead which was floating in them from the addition of the test. In the second series, with the brass slips, the action was increased in intensity, while the order was a little changed, as is here expressed: Nos. 9, 5, 7, 6, 8, 4. No. 4, in this case, was more than twice as intense in color as before. These results clearly indicate the propriety of avoiding the use of leaden pipes, if possible, in the distribution of the Quebec waters. They show that one of the purest (viz. No. 4,) is contaminated most of all by this poison, and that those which are least pure have escaped nearly unharmed. The action on the lead, it is seen, is most to be dreaded, when no indication of it is found from the tarnishing of the metallic surface. Indeed, it may be safely inferred, that the tarnishing of the lead in Nos. 8 and 9, is the principal cause of the water of these samples being saved from contamination. It may be said, that in actual use, the aqueduct water never stands long in contact with lead; but in answer to this it is remarked, that in the experiment here detailed, but little change took place after the first few hours. It is also a fact under the writer's observation, that aqueduct water may be contaminated with lead, even when the stream of water is passing through the leaden pipe unceasingly. A. B., a respectable farmer in this vicinity, had for many years suffered from indisposition of an anomalous character, and was subject to occasional paroxysms of acute and distressing pain, resembling painters' colic. As there was nothing in his occupation to authorize any inference that he was the victim of that disease, the real cause of his sufferings lay for a long time concealed, and he was treated by his medical attendants for various complaints, and with little or no amelioration. By the advice of an eminent surgeon, who, in his practice, had met with similar cases, the inquiry was made in what way water was procured for his domestic use, when it appeared that a spring of water upon a hill, at many rods distance, was brought to his door in a leaden pipe. A sample of the water was procured, and brought to the writer for examination. It proved to be strongly contaminated with lead; the use of this water

was immediately discontinued, the patient treated with the proper antidotes to lead poisoning, and his amendment confirmed the correctness of the diagnosis. This case is cited, out of hundreds of cases of lead poisoning, to show that it may not always be necessary for the water to remain any considerable time in contact with lead in order to produce contamination.

But it remains to consider how the union of leaden pipes with the iron mains may affect the predisposition of the water to act on lead. As iron is more easily rusted than lead, so it might be inferred with some plausibility that the union of the two would, on well-known galvanic principles, aid in protecting the lead. We shall see that this inference cannot be safely trusted. I have kept the waters of 5, 6, 8, and 9 for some time in contact with cast iron in close vessels. It was immediately and deeply rusted in all, and little lines of concretionary oxyd and carbonate of iron were formed in ridges over its surface, while the water became in each case quite turbid from the floating particles of free oxyd of iron suspended in it. Water is deprived of all, or nearly all, of its carbonic acid by the action of iron and the oxygen of the dissolved air, (which is known to be present in larger relative proportions to the nitrogen than in the air) is also nearly all removed. From the abundance of the bulky rust of iron produced in this way and from its adhering so feebly to the walls of the iron pipes, it cannot fail of being carried forward by the current of water moving through the pipes, and come into contact with the leaden conduits. As the water has, by the action just described, lost its carbonic acid, that substance is no longer present to aid in forming a coating of carbonated oxyd of lead, which (as has been seen in Nos. 8 and 9,) would materially aid in protecting the lead. Moreover, the contact of the pulpy free oxyd of iron with the leaden pipes, must result in the production of oxyd of lead at the expense of the oxyd of iron, which will thus part with a portion of its oxygen to unite with the lead, and the water at once takes up its quota of this deadly compound.

We confidently state, therefore, the important fact, that the passage of water through iron pipes, prepares it for a more speedy and certain action on lead. To this cause I look for an explanation of the fact, that several alleged cases of lead poisoning have happened in the city of New York; although the experiments made by me with the Croton water on lead, had appeared to authorize the inference that it would be safe to employ lead for the distribution of that water.

It must be admitted, however, that as far as our present knowledge of facts goes, the cases of poisoning with lead in

New York have been rare exceptions: but the public attention has as yet, not been fully awakened to the subject, and when it is, probably more evidence of deleterious consequences will be made known. At least, one well attested case has been recorded in England, in which water that had for years passed uncontaminated through leaden pipes, and been collected in leaden cisterns, was afterward passed through *iron* pipes, and received as before, in leaden cisterns, when it was found that the lead was rapidly corroded. The view already presented of the action of water on iron, in connection with lead, will explain this case.

I have dwelt thus fully on the subject of conducting water through leaden pipes, because it appears to me that too much attention can hardly be given to a question which is of such momentous consequences as regards the health of the community. And surely no great city in this enlightened age will propose to supply itself with water in this manner without at first demanding all the facts.

In conclusion, I may be permitted respectfully to ask whether the possibility — may we not say almost certainty — that the waters of both the Montmorenci and St. Charles will be seriously contaminated by contact with lead, is not a sufficient reason why the authorities of Quebec, as the guardians of the public health, should prohibit the distribution of its waters through this dangerous metal.

Doubtless the skill of their engineer and the fertile invention of our countrymen will contrive a safe and economical substitute.

All which is respectfully submitted by
Your obedient servant,

B. SILLIMAN, Jr.

ANALYTICAL LABORATORY, YALE COLLEGE,
NEW HAVEN, MARCH 27, 1848.

P. S. The writer may be permitted to add, that by his advice, a pipe of copper, well coated with pure tin, has been in use for some years in a well in New Haven, with entire success. Should the Quebec waters fail to coat over the inner surface of the lead pipes with the covering of organic matter, before alluded to, thus rendering a substitute not necessary — this description of copper pipe would probably be the best resort.

APPENDIX B.

DWELLINGS, MANUFACTORIES, AND INSTITUTIONS

SUPPLIED WITH THE SCHUYLKILL WATER IN

THE CITY OF PHILADELPHIA.

TO 31st DECEMBER, 1821

		Dolls.	cts	Dolls.	cts
48	Water closets, &c. at	1	00	48	00
138	Wash pavements, &c.	2	00	276	00
254	Tenements	2	50	635	00
2337	Baths	3	00	7,011	00
11	Taverns	3	75	41	25
52	Stables	4	00	208	00
9929	Dwellings, &c.	5	00	49,645	00
1	Stable, &c.			5	50
35	Dwellings, &c.	6	00	210	00
4	Dwellings, &c.	7	00	28	00
86	Courts, &c.	7	50	645	00
544	Printing-offices, &c.	8	00	4,352	00
2	Dwellings, &c.	8	50	17	00
33	Vinegar yards, &c.	9	00	297	00
2	Steam engines, &c.	9	50	19	00
193	Dyers, &c.	10	00	1,930	00
1	Dwelling, &c.			10	50
4	Marble yards	11	00	44	00
6	Dwellings, &c.	11	25	67	50
22	Soap-boilers, &c.	12	00	264	00
38	Dwellings, &c.	12	50	475	00
4	Taverns, &c.	13	00	52	00
3	Courts, &c.	14	00	42	00
63	Distilleries, &c.	15	00	990	00
5	Hatteries, &c.	16	00	80	00
3	Stables, &c.	17	00	51	00
3	Courts, &c.	17	50	52	50
5	Courts, &c.	18	00	90	00
39	Taverns, courts, &c.	20	00	780	00
1	Steam engine, &c.			20	50
11	Courts, &c.	22	50	247	50
2	Stables, &c.	24	00	48	00
28	Sugar houses, &c.	25	00	700	00
1	Court, &c.			26	00
4	Taverns, &c.	27	50	110	00
1	Tavern, &c.			29	50
27	Stables, &c.	30	00	810	00
1	Steam engine, &c.			31	75
1	Court, &c.			32	50
3	Courts, &c.	33	00	99	00
1	Mansion house			34	00
13,949	Amount carried forward			70,555	00

APPENDIX B. — *Continued.*

		Dolls.	cts	Dolls.	cts
13,949	Amount brought forward			70,555	00
9	Hotels, &c.	35	00	315	00
4	Steam engines, &c.	36	00	144	00
2	Steam engines, &c.	39	00	78	00
6	Steam engines, &c.	40	00	240	00
1	Court, &c.			41	25
1	Court, &c.			44	00
3	Courts, &c.	45	00	135	00
14	Stables, &c.	50	00	700	00
1	Hotel			53	00
1	Hotel			55	00
1	Steam engine, &c.			54	00
4	Hotels, &c.	60	00	240	00
1	Hotel			61	00
1	Hotel			64	00
1	Hotel			65	00
1	Tavern, &c.			70	00
6	Water wheels	75	00	450	00
1	Hotel			86	00
1	Hotel			88	00
1	Laboratory			80	00
1	Hotel			96	50
1	Bath house			110	00
2	Baths, &c.	125	00	250	00
1	Naval Asylum			140	00
1	Brewery			124	50
1	Brewery			128	00
1	Bath house			138	00
2	Sugar houses	150	00	300	00
1	Gas works			400	00
1	Sugar house			750	00
14,021	Total for city			70,055	25
DISTRICT OF SOUTHWARK.					
<i>After deducting 15 per cent., the 50 per cent. on city rates having been taken off.</i>					
19	Bake houses, &c.	2	50	47	50
62	Baths	3	00	249	00
1,942	Dwellings	5	00	9,710	00
2	Steam engines, &c.	6	00	12	00
8	Bars, &c.	3	75	30	00
29	Courts, &c.	7	50	217	50
15	Dwellings and baths	8	00	120	00
5	Bars, &c.	8	75	43	75
1	Stable, &c.			9	50
1	Tavern, &c.			9	75
33	Dwelling, &c.	10	00	330	00
4	Hatteries	12	00	48	00
18	Soap chandlers, &c.	15	00	270	00
16,181				87,152	25

APPENDIX B. — *Continued.*

		Dolls.	cts	Dolls.	cts
16,181	Amount brought forward			87,152	25
1	Bath and tenements				15 50
1	Stable, tenements, &c.				16 34
4	Tenements, hatteries, &c.	17	50		70 00
1	Tavern and stables				19 50
5	Courts, &c.	20	00		100 00
12	Courts, &c.	12	50		150 00
5	Courts, &c.	25	00		125 00
1	Court, &c.				27 50
2	Courts, &c.	30	00		60 00
1	Steam engine, &c.				30 67
2	Courts, &c.	35	00		70 00
1	Brewery				45 00
1	Distillery				50 00
1	Foundry				58 67
1	Steam engine				60 00
1	Navy yard, &c.				75 00
1	Vagrant apartment of county prison				100 00
1	County prison				400 00
16,223	Total for City and Southwark			88,625	43
DISTRICT OF MOYAMENSING.					
<i>After deducting 15 per cent. The 50 per cent. on city rates having been taken off.</i>					
2	Water closets	1	00		2 00
4	Bakers	2	50		10 00
2	Bars	3	75		7 50
52	Baths, &c.	3	00		150 00
517	Dwellings, &c.	5	00		2,585 00
1	Factory				6 66
2	Bakers, &c.	7	00		14 00
8	Courts, &c.	7	50		60 00
10	Dwellings and baths	8	00		80 00
7	Taverns, &c.	8	75		61 25
7	Courts, &c.	10	00		70 00
5	Courts, &c.	12	50		62 50
1	Public school				13 34
5	Dyeries, &c.	15	00		75 00
2	Courts	17	50		35 00
3	Courts, &c.	20	00		60 00
1	Court, &c.				22 50
1	Court, &c.				25 00
1	Factory				30 00
1	Dwelling, &c.				35 00
1	Dwelling, &c.				40 00
1	Dwelling, &c.				95 00
1	Water wheel, &c.				116 67
16,858	Total for City, Southwark, and Moyamensing			92,287	85

The water rents for Southwark and Moyamensing are due, and payable to the city on the 1st June, 1845.

APPENDIX C.
NEW YORK WATER WORKS, FOR THE YEAR 1844.
TABULAR STATEMENT OF THE DIFFERENT PURPOSES FOR WHICH THE WATER IS USED.

Number of private dwellings and other establishments supplied with water.		Rate per ann.	Amount.	Number of private dwellings and other establishments supplied with water.		Rate per ann.	Amount.
		\$ cts.	\$ cts.				\$ cts.
61 Dwellings	.	5 00	305 00	4932 Amount brought up	.		50,479 00
63 "	.	6 00	378 00	88 Steam engines	.		4,600 50
13 "	.	6 66	86 00	94 Stables	.		1,452 00
137 "	.	7 00	959 00	17 Bathing establishments	.		1,235 00
698 "	.	8 00	5,534 00	259 Dwellings and stores	.		3,421 25
550 "	.	9 00	4,950 00	59 Public houses	.		3,467 50
1512 "	.	10 00	15,120 00	125 Bar houses	.		1,405 50
4 "	.	10 50	42 00	77 Refectories	.		1,594 00
155 "	.	11 00	1,705 00	62 Public institutions	.		1,360 00
1597 "	.	12 00	19,164 00	210 Boarding-houses	.		3,569 00
27 "	.	13 00	351 00	45 Slaughter-houses	.		592 00
33 "	.	14 00	462 00	527 Stores and offices	.		6,654 00
34 "	.	15 00	510 00	235 Manufacturing purposes	.		6,254 00
14 "	.	16 00	224 00	75 Mechanical	.		1,124 00
4 "	.	17 00	68 00	14 Fountains	.		297 00
17 "	.	18 00	306 00	43 Steamboats	.		3,628 47
12 "	.	20 00	240 00	5 Hair-dressing rooms	.		33 00
1 "	.		25 00	18 Street sprinklers, filling ships, &c.	.		1,104 76
				34 do.	.		334 75
4932			\$ 50,479 00	6919			\$ 92,625 73

Average rate for dwellings, is \$ 12 per annum.

APPENDIX D.—STATISTICS OF FOREIGN WATER WORKS.

COMPILED FROM PUBLISHED ACCOUNTS.

APPENDIX.

89

	Year.	Imperial gallons supplied to a tenant in 24 hours.	Cubic ft. supplied to a tenant in 24 hrs.	Imperial galls. supplied in the district, calling as Imperial.	Number of houses or establishments supplied in each district.	Annual amount of water rent or income, in £. for each district.	Water rent from the commencement.	Total cost of works up to date, in £.	Average annual charge to tenant in shillings per year.
New River,	1804	185.6	31.40	11,556,000	54,681	63,678			23.29
"	1809				59,058	80,782			27.36
"	1820	190.3	30.54	9,912,330	52,082	67,275		954,868	25.83
East London,	1827	173.6	27.86	11,556,000	66,559	95,657		1,038,725	28.74
"	1820	136.2	21.85	4,366,800	32,071	35,359		347,000	22.05
West Middlesex	1827	155.0	24.88	6,512,292	42,000	45,443		513,204	21.64
"	1820	174.0	27.91	1,800,389	10,350	24,252		318,834	46.86
Chelsea	1827	155.2	24.90	2,250,000	14,500	37,000		374,567	51.03
"	1804				8,424	11,220		138,648	26.64
"	1809	143.9	23.10	1,364,220	9,477	14,702			31.03
"	1820	129.1	20.72	1,114,600	8,632	15,150			35.10
Grand Junction,	1827	154.7	24.83	1,920,000	12,409	18,590		70,000	29.96
"	1820	270.0	43.52	1,838,670	7,180	29,153		219,858	56.14
Lambeth,	1827	284.3	45.61	2,800,000	9,850	24,702	230,534	312,669	50.16
"	1820				11,487	9,335			16.25
South London,	1827	92.6	14.86	1,480,500	15,987	12,370		130,084	15.47
"	1820				5,200	4,708		incomplete.	18.11
Southwalk,	1827	100.0	16.05	1,000,000	10,000	8,293		102,000	16.58
Exeter, England	1827	227.9	36.56	1,572,400	6,900	3,400		70,000	15.47
Glasgow, Scotland	1844	109.9	17.63	373,626		2,631			
Manchester, England	1829	109.4	17.55	3,500,000	160,000				
Water Works, North side the Thames	1820	82.8	13.28	1,241,736	15,000				
"	1827	173.4	27.83	19,132,789	110,315	162,189			
The eight London Water Companies	1827	172.3	27.64	25,038,292	145,318	221,392		2,369,165	29.40
"	1827	163.2	26.19	29,091,192	178,205			2,611,249	30.47
New River, London, (omitting large consumers)	1841	153.1	24.50		81,555				
"	1842								
"	1843								

APPENDIX F.

THERMOMETRICAL OBSERVATIONS.

Made at the Seminary of Quebec during the months of October, November, December 1846,—January, February, March, April, May, June and July, 1847. (Fahrenheit.)

		Means.				6 A. M.	Noon.	6 P. M.
		From	1st	to 10th	inclusive			
1846	October	"	11	"	20	45,482	50,110	44,623
		"	21	"	31	37,532	45,983	43,449
		"	21	"	31	23,135	35,044	33,976
"	November	"	1	"	10	36,100	45,942	44,812
		"	11	"	20	36,450	41,391	39,065
		"	21	"	30	26,620	30,391	28,524
"	December	"	1	"	10	14,475	22,633	21,500
		"	11	"	20	18,351	23,285	20,675
		"	21	"	31	11,329	16,748	15,295
1847	January	"	1	"	10	14,860	19,032	17,839
		"	11	"	20	2,375	10,000	7,567
		"	21	"	31	0,378	7,976	5,249
"	February	"	1	"	10	16,089	23,875	22,265
		"	11	"	20	1,850	13,845	9,805
		"	21	"	28	1,156	14,612	14,321
"	March	"	1	"	10	7,500	21,282	17,908
		"	11	"	20	10,700	26,058	24,825
		"	21	"	31	18,225	29,067	24,734
"	April	"	1	"	10	25,875	40,962	35,333
		"	11	"	20	24,300	38,699	35,115
		"	21	"	30	32,417	38,462	31,656
"	May	"	1	"	10	52,000	40,216	53,448
		"	11	"	20	51,069	46,416	55,441
		"	21	"	31	57,031	51,437	63,250
"	June	"	1	"	10	57,071	66,083	66,475
		"	11	"	20	58,833	66,490	63,675
		"	21	"	30	64,191	75,991	72,515
"	July	"	1	"	10	65,722	80,870	79,554
		"	11	"	20	73,063	75,906	71,794
		"	21	"	31	64,708	70,260	69,550

APPENDIX F. — *Continued.*

State of the greatest cold, and the average degree of cold for eight years, at Quebec.

Year.	Farenheit's Thermometer.	
	Average cold.	Coldest.
	Deg.	Deg.
1829 . . .	. . . 33 . . .	-39 January 4th.
1830 . . .	. . . 33 . . .	-41 " 31st.
1831 . . .	. . . 22 . . .	-39 " 21st.
1832 . . .	. . . 25 . . .	-33½ February 24th.
1833 . . .	. . . 30 . . .	-36½ January 19th.
1834 . . .	. . . 24 . . .	-36½ December 15th.
1835 . . .	. . . 30 . . .	-33½ February 4th.
1836 . . .	. . . 26 . . .	-35½ Feb. 2d & Dec. 31.
		Under zero.

Copy, GREAVES CLAPHAM.

(Signed)

J. WATT.

Maximum and minimum of thermometer in Lower Canada, for the six coldest months, from 1822 to 1834, inclusive. Taken from a published table, arranged by Maj. Stack, of the 24th regt. while quartered in Lower Canada, from 1829 to end of 1834, by setting down the hottest day and the coldest night in each month. The table previous to the commencement of his diary was taken from a Meteorological Diary, published by a scientific gentleman in Quebec.

Months.		1822	1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	Mean.	Mean Diff.
November	Max.	48	46	48	60	42	44	46	50	58	50	54	46	51	50	} 37
	Min.	16	2	14	10	14	8	15	8	20	20	17	11	8	13	
December	Max.	40	42	44	40	44	35	38	44	57	43	25	43	48	42	} 53
	Min.	-23	-13	-21	-25	5	7	-19	-7	-9	2	-8	-3	-24	-11	
January	Max.	42	40	44	38	36	36	42	40	32	43	50	43	43	41	} 62
	Min.	-24	-20	-17	-12	-10	-25	-27	-26	-18	-24	-21	-31	-21	-21	
February	Max.	47	44	50	46	46	42	44	25	51	42	34	45	47	43	} 63
	Min.	-16	-18	-31	-20	-26	-28	-12	-12	-24	-21	-29	-16	-9	-20	
March	Max.	15	46	48	52	42	42	52	50	70	52	50	52	54	51	} 54
	Min.	1	-17	2	4	8	-1	-6	-1	-1	-1	-12	-12	0	-3	
April	Max.	56	58	53	56	57	62	60	60	82	56	49	62	82	61	} 47
	Min.	9	6	11	11	5	24	10	27	29	10	-1	18	20	14	

APPENDIX G.

FAIRMOUNT WATER WORKS, PHILADELPHIA.

STATEMENT SHOWING THE AMOUNT OF THE DIFFERENT HEADS OF EXPENDITURE,
EMBRACING ALL ACCOUNTS FOR THE CITY.

	1840.	1841.	1842.	1843.	1844.	1845.	Average of the six yrs.
Distribution	4,198.93	3,874.83	3,569.65	4,925.43	3,321.30	4,623.43	3,957.26
Fairmount Works	6,275.71	7,199.68	8,634.96	5,913.16	5,970.10	5,598.10	6,598.60
Iron Pipes	4,978.98	3,463.27	5,091.68	3,014.23	8,249.91	6,265.41	5,176.08
Wheels and Pumps				19,464.09			
Water Power	2,920.96	3,065.38	2,453.94	2,541.42	2,249.82	2,849.03	2,680.07
Incidentals	237.85	238.69	548.07	1,925.56	1,397.97	1,305.96	950.68
Salaries	3,860.00	3,860.00	4,090.00	4,200.00	3,150.00	5,250.00	4,068.33
Fairmount Dam			39,523.20	16,693.65			
Forebay Gates				2,994.55			
Twelve inch main				2,199.75	5,381.25		
Wire bridge at Fairmount		3,000.00					
	29,452.44	94,701.75	63,911.40	63,171.84	29,713.35	25,891.93	

APPENDIX E.

STATISTICS OF FAIRMOUNT WATER WORKS.

COMPILED FROM THE ANNUAL REPORTS.

1.	2.	3.	4.	5.	6.	7.
	Year, inclusive.	Imperial gallons of water supplied to each tenant in 24 hours.	Cubic feet of water supplied to each tenant in 24 hours.	Average gallons of water supplied to city and districts for each 24 hours, (including free water takers, since 1833.)	Number of tenants supplied, including the free water takers, when known.	Amount of water rents per annum.
For the year	1801				34	2
"	1802					5
"	1803				267	9
"	1804				345	1,8
"	1805					3,2
"	1806					5,0
"	1807					4,9
"	1808					6,2
"	1809				1,590	9,1
"	1810					10,9
"	1811				2,127	12,1
"	1812				2,602	15,6
"	1813				2,984	16,6
"	1814					17,8
"	1815					18,5
"	1816					19,9
"	1817			879,688		19,9
"	1818					21,1
"	1819					21,9
"	1820				4,170	23,0
"	1821					24,5
"	1822				4,758	25,4
"	1823					26,1
"	1824	325.0	52.15	1,643,710	5,057	27,2
"	1825				5,352	29,1
"	1826	184.0	29.52	1,128,200	6,132	33,5
"	1827				7,493	42,9
"	1828				8,769	51,0
"	1829				9,603	56,6
"	1830				10,343	63,6
"	1831	178.3	28.62	2,034,090	11,406	70,4
For Summer months.	"	167.5	42.92	3,051,130		
For the year	1832				12,444	71
"	1833				13,984	85,5
"	1834	204.7	32.84	3,457,950	16,895	90,5
For July and August (dry time)	"	301.0	48.30	5,085,220		
For the year	1835	190.2	30.52	3,557,260	18,704	99,8
For Summer months	"	217.5	34.90	4,068,180		
For October and November	"	182.9	29.36	3,420,970		
For December 3d	"	137.2	22.02	2,566,240		
For the year	1836	161.4	25.90	3,175,920	19,678	106,4
From February 1st to 21st, (very cold)	"	91.5	14.68	1,799,960		
" February 21 to March 20	"	109.2	17.53	2,149,280		
" March 20 to June 3	"	157.4	25.26	3,098,040		
" June 3 to July 22	"	203.8	32.70	4,009,840		
" July 22 to September 9	"	214.6	34.44	4,223,710		
" September 9 to October 28	"	190.2	30.52	3,742,520	20,462	
" October 28 to December 31	"	163.0	26.16	3,207,870		
For the year	1837	171.8	27.57	3,515,320	21,947	121,1
"	1838	178.4	28.63	3,916,280		
From January 1 to April 1	"	121.8	19.55	2,673,230	21,947	
" April 1 to July 1	"	182.7	29.32	4,009,840		
" July 1 to October 1	"	238.7	38.31	5,230,530		
" October 1 to December 31	"	170.5	27.36	3,742,520		
For the year	1839	178.7	28.68	4,046,170		
From January 1 to April 1	"	134.0	21.50	3,032,380		

PENDIX E. NT WATER WORKS, PHILADELPHIA. FROM THE ANNUAL REPORTS.

5.	6.	7.	8.	9.	10.	11.	12.	13.
Average gallons of water supplied to city and districts for each 24 hours, (including free water takers, since 1833.)	Number of tenants supplied, including the free water takers, when known.	Amount of water rents per annum.	Amount of water rents from commencement of works in 1801.	Total cost of the water-power works and iron pipes.	Total miles of iron pipe, including mains from reservoir, up to each year, inclusive.	Total number of fire-plugs, up to each year, inclusive.	Free water takers from street pumps, included in column 3.	Average annual charge to tenant, in dollars and cents.
	34	278						8 18
		537						
	267	961						3 60
	345	1,800						5 22
		3,260						
		5,050						
		4,987						
		6,207						
	1,590	9,105						5 73
		10,931						
	2,127	12,163						5 72
	2,602	15,629						6 00
	2,984	16,638						5 58
		17,883						
		18,500						
		19,975						
879,688		19,922						
		21,120						
		21,998						
	4,170	23,016			1.81			5 52
		24,584			3.42			
	4,758	25,485			6.45			5 35
		26,191			9.29			
1,643,710	5,057	27,293			13.17			5 40
	5,352	29,160			15.33			5 45
1,128,200	6,132	33,509			22.97			5 46
	7,493	42,900			38.83			5 72
	8,769	51,020			47.85			5 82
	9,603	56,603			55.36			5 90
	10,343	63,614			63.05			6 15
2,034,090	11,406	70,403	665,329	1,138,323	67.57			6 17
3,051,130		71,337			72.86			6 23
		85,539			78.07			6 11
		90,531	898,840		82.25	740	2,500	5 36
3,457,950	16,895	99,848	1,036,830		93.04	852	3,000	5 34
5,085,920								
3,557,260								
4,068,180								
3,420,970	18,704							
2,566,240								
3,175,920								
1,799,960								
2,149,280	19,678	106,432	1,143,000	1,381,031	98.74	907	3,000	5 41
3,098,040								
4,009,840								
4,223,710								
3,742,520	20,462							
3,207,870								
3,515,320								
3,916,280								
2,673,230	21,947	121,151	1,371,873	1,453,404	106.38	981	say 3,500	5 52
4,009,840								
5,230,530								
3,742,520								
4,046,170								
3,032,380								

For July and August (dry time)				301.0	48.30	5,085,220	18,704
For the year	1835	190.2	30.52	3,557,260			
For Summer months		217.5	34.90	4,068,180			
For October and November		182.9	29.36	3,420,970			18,704
For December 3d		137.2	22.02	2,566,240			
For the year	1836	161.4	25.90	3,175,920			
From February 1st to 21st, (very cold)		91.5	14.68	1,799,960			
February 21 to March 20		109.2	17.53	2,149,280			
March 20 to June 3		157.4	25.26	3,098,040			19,678
June 3 to July 22		203.8	32.70	4,009,840			
July 22 to September 9		214.6	34.44	4,223,710			
September 9 to October 28		190.2	30.52	3,742,520			
October 28 to December 31		163.0	26.16	3,207,870			
For the year	1837	171.8	27.57	3,515,320			20,462
For the year	1838	178.4	28.63	3,916,280			
From January 1 to April 1		121.8	19.55	2,673,230			
April 1 to July 1		182.7	29.32	4,009,840			21,947
July 1 to October 1		238.7	38.31	5,239,530			
October 1 to December 31		170.5	27.36	3,742,520			
For the year	1839	178.7	28.68	4,046,170			
From January 1 to April 1		134.0	21.50	3,032,380			
April 1 to July 1		196.0	31.46	4,437,560			22,636
July 1 to October 1		205.5	32.97	4,661,420			
October 1 to December 31		179.5	28.80	4,063,310			
For the year	1840	174.7	28.04	4,103,410			
From January 1 to April 1		143.4	23.02	3,368,270			
April 1 to July 1		184.4	29.59	4,330,630			23,482
July 1 to October 1		207.2	33.25	4,865,280			
October 1 to December 31		163.9	26.30	3,849,450			
For the year	1841	179.1	28.73	4,445,630			
From January 1 to April 1		129.2	20.74	3,279,940			
April 1 to July 1		183.9	29.50	4,564,240			24,828
July 1 to October 1		232.6	37.32	5,774,170			
October 1 to December 31		178.7	28.68	4,437,550			
For the year	1842	169.3	27.17	4,370,730			
From January 1 to April 1		145.0	23.26	3,742,520			
April 1 to July 1		176.0	28.25	4,544,490			25,816
July 1 to October 1		205.0	32.90	5,292,990			
October 1 to December 31		116.3	18.66	3,002,910			
For the year	1843	169.4	27.18	4,497,780			
From January 1 to April 1		141.7	22.74	3,763,060			
April 1 to July 1		173.2	27.78	4,597,050			26,549
July 1 to October 1		203.2	32.60	5,394,710			
October 1 to December 31		156.9	25.17	4,165,203			
On September 15 and 16		229.9	36.88	6,102,260			
For the year	1844	193.0	30.98	5,421,310			
From January 1 to April 1		132.4	21.24	3,716,810			
April 1 to July 1		197.2	31.64	5,538,100			28,082
July 1 to October 1		251.7	40.39	7,068,370			
October 1 to December 31		176.4	28.31	4,955,140			
For the year { Some of the districts declined. }	1845	207.7	33.33	4,187,740			
From January 1 to April 1		155.6	24.97	3,138,040			20,165
April 1 to July 1		229.8	36.87	4,633,600			
July 1 to October 1		261.6	41.98	5,275,160			
October 1 to December 31		183.7	29.48	3,704,160			

TABLE CONTINUED FOR OTHER

New York to 1st May,	1843				17
" " "	1844				9
" " "	1845			9,800	11
" " "	1846			12,217	16
" " "	1847			14,961	19
" " "	1848				
Boston to December 1	1847			none.	none.
Quebec, proposed	"	150.	24.07	3,000,000	20,000

18,899	99,848	1,036,830	93.04	852	3,000	5 34
18,704	99,848	1,036,830	93.04	852	3,000	5 34
19,678	106,432	1,143,000	1,381,031	98.74	907	3,000 5 41
20,462						
21,947	121,151	1,371,873	1,453,404	106.38	981	say 3,500 5 52
22,636	127,234	1,499,107	1,464,146	109.88	1,007	3,100 5 62
23,482	133,455	1,630,840	1,472,598	111.50	1,025	3,100 5 68
24,828	141,340	1,772,184	1,483,300	113.50	1,045	3,300 5 69
25,816	148,400	1,918,804	1,493,688	115.25	1,055	3,300 5 75
26,549	153,608	2,067,609	1,584,594	117.50	1,070	3,300 5 79
28,082				120.88	1,099	3,500
20,165	98,813	2,256,791	83.75	744	3,500	4 90

INUED FOR OTHER CITIES.

none.	none.	none.	none.	1,442,951	30.04	600	none.	none.
3,000,000	20,000	17,839	91,790	10,900,000		600	12 35	
		9,600	118,582				13 46	
		12,217	164,532		171.00		13 00	
		14,961	194,551					